Bureau of Standards.
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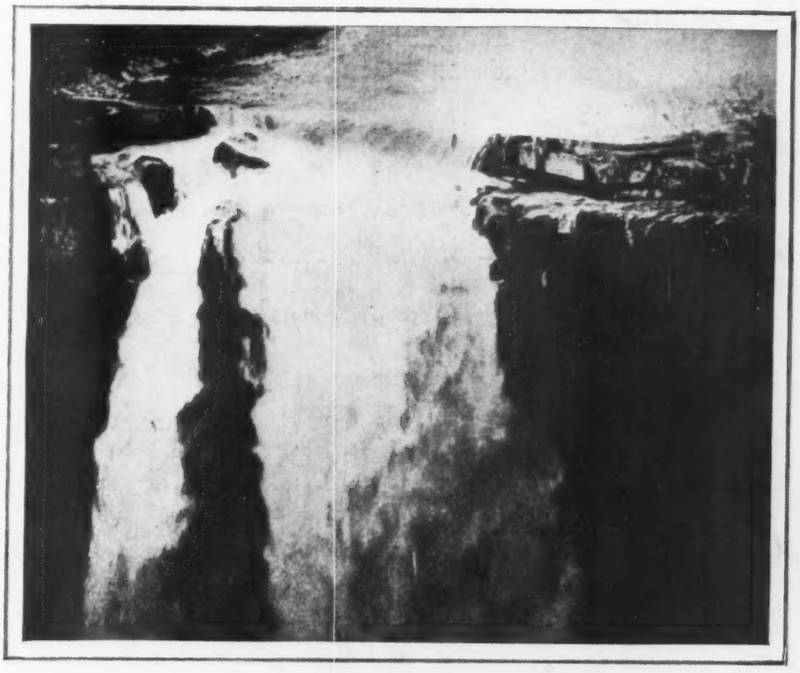
THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED



CANADIAN WATER POWER

See Page 206

FEBRUARY 1922

VOL. II NO. 8

Stored in Unheated Shack, Soaked in the Icy Creek, Placed on Ice at 7 Above Zero, Du Pont Low-Freezing Straight Showed No Signs of Freezing

"…. excellent results obtained from your Low-Freezing Straight Dynamite…. Stored in a frame shack with no protection from the cold whatever…. had cold snaps when the thermometer was at or near zero for three or four days at a time, and this dynamite, upon examination, proved to be in as good condition as in warm weather…. was perfectly soft and pliable.

"It has been my experience that dynamite which has become wet freezes very readily…. I placed six sticks in the creek where we left it for several minutes; then we placed it on the ice-covered portions of the creek where we left it for perhaps a half hour…. it showed no indication of freezing. We then left these sticks out on the ground near the magazine, where they remained for more than 24 hours…. found them in perfect condition, the cold not having affected them in the least. The temperature was from 7 to 15 degrees above zero.

"This dynamite gave us most satisfactory results in our work."

(Excerpt from letter received from a user)

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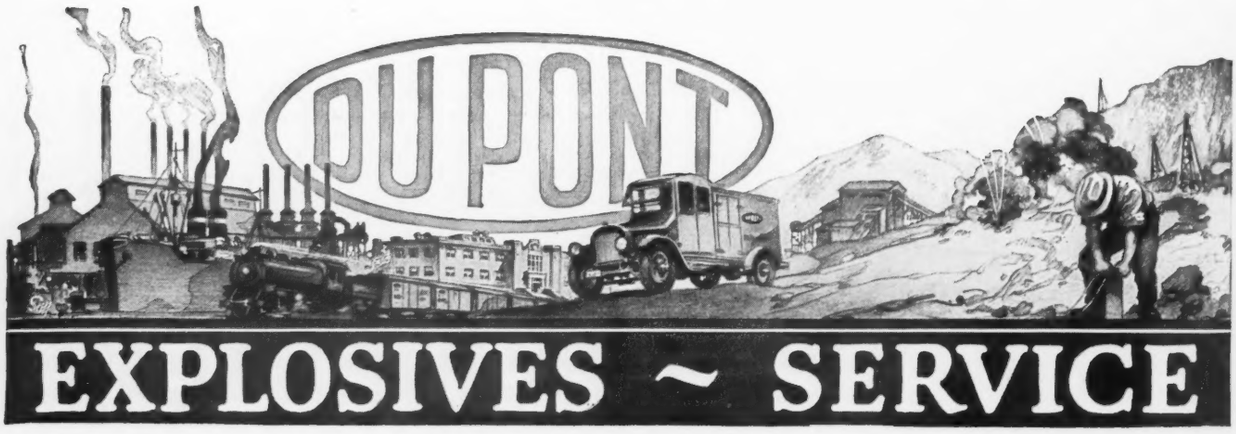

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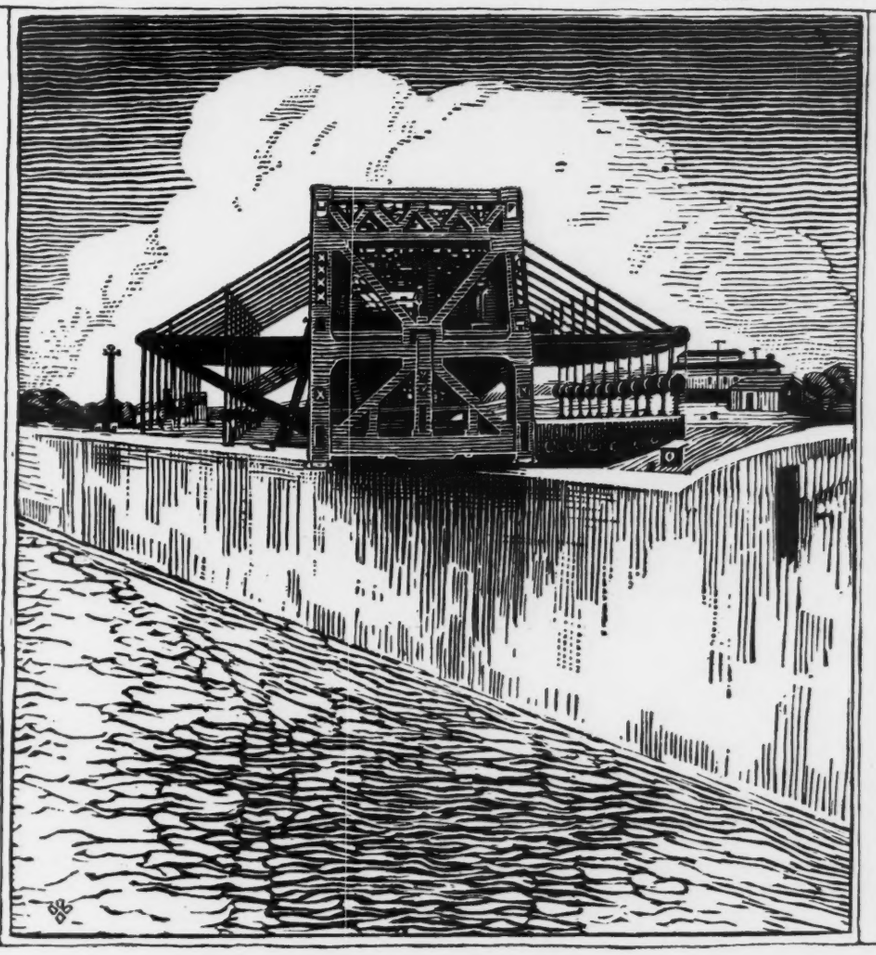

The WORLD'S WORD for ELEVATOR SAFETY

The WORLD'S WORD for ELEVATOR SAFETY

PANAMA CANAL EMERGENCY DAMS

GATUN LAKE, eighty-five feet above sea level, is the reservoir holding the water to feed the Gatun Locks (which lead to the Atlantic) and the Miraflores and Pedro Miguel locks on the Pacific end of the canal.

Every ship going through the canal in either direction uses the water from Gatun Lake to lift it from the one ocean and lower it into the other. Should some accident destroy a lock, the weight of the water released might force down the others and cause tremendous damage and, by lowering the level of the lake, make the canal inoperative until rain had refilled the lake.

Therefore these big emergency dams were constructed. Normally they are not used. In emergencies they would be swung over the locks, the gates would drop into position and effectually dam the opening.

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The organic chemical industry holds the germ of progress in all industries, and the discoveries and inventions of the future are hidden in the laboratories of its research branches.

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The Tech Engineering News

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COURSE X-A

By RAYMOND A. ST. LAURENT, '21

What do you know about actual Chemical Engineering if you haven't taken X-A?

X-A is a real course from many points of view. Although our work in it is not finished until June, so far the money and time investment is surely warranted. Briefly, some of the main benefits are: first, the development of an ability to meet on common grounds and get along with under all conditions, not only your classmates, but all kinds of workmen, from ignorant "hunkies" through intelligent classes of common laborers to hard-boiled foremen and likeable superintendents; second, the cultivation of the powers of perception and reasoning in following out important industrial processes; third, the realization that good health and stamina are necessary in order to stand the physical and mental strain of long shifts; and finally, the further development of the ability to lead and direct men. Don't think that all of us have perfected ourselves in all these phases, but we now realize their importance and have had ample opportunity to greatly improve ourselves.

Investigations of vital importance have been run at Larkin Co., Inc., Lackawanna Steel Co., Eastern Manufacturing Co., Penobscot Chemical Fibre Co., Merrimac Chemical Co., United States Rubber Co., and the Revere Sugar Refinery. Class room and laboratory work is carried to the plant, and how things do change by this slight transition! The scale of operation is completely altered. In our investigations, we have found raw materials going in and finished products coming out by the hundreds of tons, yet we, as chemical engineers, must gage, analyze, interpret, and follow in detail the entire process. For example, a coke test on a block of sixty Semet Solvay Ovens, using one and three-quarter million pounds of coal and over three million cubic feet of fuel gas per day, producing a million and a quarter pounds of coke, nine and a half million cubic feet of fuel gas, and one thousand gallons of tar per day, as well as large amounts of ammonia and benzol, required the measurement and analysis of all these materials. Heat losses and efficiencies were also determined. It was a twenty-seven hour test, with little chance to rest, conducted by the eleven men at the station, with one professor and two assistants. One of our eleven was in charge and responsible for the success of the test. It was a real test, the results of which showed to the last detail how this $4,000,000 plant was operating.

The chemical industries of the United States demand more insistently each year that there be provided training which will more nearly produce a potential chemical engineer. While the four year course in Chemical Engineering at the Institute is broad in its scope, it cannot give a systematic knowledge, acquired by direct contact in the works, of the most important types of structures and processes involved in the chemical industries. It was to furnish this most essential element that the School of Chemical Engineering Practice, as X-A is officially known, was established, and the records of its graduates give eloquent testimony of its value.—Editor

But all of our life is not work. In Buffalo, we lived at a club house run exclusively for the group, where we really enjoyed life. What had originally been the parlor of the house had been converted into a pool room, where many an exciting evening was spent "racking them up." A phonograph, piano, ukes and banjos with husky voices accompanying soothed tired nerves after a day's work. Voices which never sang before developed much with nightly practice and are now able to attract great attention, though little applause.

One day we all had the opportunity to spend the afternoon at Niagara Falls; and while we were at the Larkin Company, we all attended the annual picnic of the employees at Crystal Beach, an amusement beach in Ontario, Canada. Dancing, bathing, and other pleasures at this and other resorts strongly attracted some of the group on week ends.

At the Lackawanna Steel Company plant, which borders on Lake Erie, we ate our lunches on the shore of the lake and swam in the cool waters rather to cool off, than to "whet" an appetite; and what between accidentally sitting in tar, climbing the 250 foot stack, walking miles of railroad tracks and eating soapy soup, everybody had a busy time. Old clothes were by far the most popular attire. Those who came with none soon had plenty.

Bangor was a complete change of country and work. There we followed from the log to the finished sheet of paper and studied in detail the making of paper, by two methods, with the associated chemical processes. The paper industry, as we studied it, covered the entire process from taking the log from the river, chipping it, cooking it to remove all but the fibers, washing and bleaching the wood fibers and rags, beating the fibers, to forming the sheet and finishing it. But there also, life was by no means all work.

(*Continued on Page 222*)

STUDYING PAPER MAKING AT THE BANGOR STATION
Fourdrinier Paper Machine at the Eastern Manufacturing Company.

STARS AND ATOMS

By DR. HARLOW SHAPLEY

Director of Harvard Observatory, Cambridge, Mass.

The Massachusetts Institute of Technology is well known to astronomers and furthermore its astronomical reputation is high—much higher, perhaps, than most undergraduates realize. It is the place where leaders of astronomical science have begun their work. It is the alma mater of Dr. George E. Hale, founder and director of the world's largest observatory; also of two other students in Solar Physics of world-wide reputation, Dr. C. G. Abbott and Mr. F. E. Fowle of the Astrophysical Observatory of the Smithsonian Institute. It was in the Institute that the late Professor E. C. Pickering, one of the foremost American scientists, was for ten years Professor of Physics before he began his forty years' directorship of the Harvard College Observatory.

In telling of recent results by myself and others regarding the dimensions of our stellar system, I shall describe work in which much use was made not only of the inspiring example and splendid opportunities, but also of the scientific data, supplied by these former men of Technology.

Our present day studies of the extent, the structure, and the origin of the sidereal universe makes basic use of the older branches of physics—the measurement of length, mass, time, and light. They also bring us into touch with the more recent developments of physics and chemistry—the theory of gases and of radiation, the methods of ionization, the structure of the chemical atoms.

The trigonometric method of measuring distances in stellar space, which uses the orbit of the earth as a base line for surveying operations, yields information for only a limited region. Our base line is too short, or our instruments too clumsy, to give this triangulation procedure any importance for distant stars. The need of more comprehensive methods has led astronomers to various devices. Greater numbers of stars may be reached through using as a base line for triangulation, not the diameter of the earth's orbit, but the ever accumulating distance due to the motion of the whole solar system through space. Analyses of stellar motions across the surface of the sky and in the line of sight have given us mean parallaxes of large groups of the brighter stars.

STARS AND ATOMS

"Twinkle, twinkle, little star" runs the verse we used to say in childhood. Yet these "little stars" are larger than a hundred suns and are "up above the world so high"—higher than we can imagine. Astronomers are continually discovering new regions of the vast universe. Strange as it may seem, through the actions of these immense bodies science learns more and more of the smallest chemical unit—the atom.—Editor.

Within the last decade the so-called photometric methods of determining the distances of celestial bodies have enormously increased our knowledge of the dimensions of the stellar system. In particular, the study of two kinds of variable stars yields results that allow us to reach farther into space than has heretofore been within our power. The positions of certain objects, so remote that they are scarcely visible with the greatest telescopes, can now be deduced with some certainty, and a considerable step can be made toward a better appreciation of the extent of the sidereal universe.

The principles involved in the determination of stellar distances through measures of the quantity of light emitted and received are not complicated. As an earthly illustration let us consider a series of street lamps observed visually (or photographically) from a fixed station. To begin with, let us suppose that the lamps are all of the same candle power. To the observer, the near ones will appear bright, the distant ones faint, the brightness decreasing as the square of the distance increases. If one of these equally luminous lamps is ten times as far away as the nearest, the observer receives from it but a hundredth as much light, and it is fainter by five magnitudes, if we express the relative amount of light in the ordinary astronomical units. When the observer measures the quantity of light received from each lamp, he can compute immediately their relative distances; and then, if he determines, by triangulation or other method, the absolute distance to the nearest lamp, he may compute at once the absolute distances of all the others.

Even when the lamps are not of the same candle power the method applies as well, provided the relative candle power is known for the various types of lamp, and, by means of color, or of flickering, or otherwise, the types can be distinguished.

The problem of the distances is exactly the same for street lamps and variable stars. We distinguish the variables from other stars by the variations (flickering) and color of their light. We find from studies of motions, light variations, color, and spectra how to estimate the intrinsic candle power of the different stars. Then through ordinary methods of astronomical photometry we measure the quantity of light received from a star—its apparent brightness—and immediately derive the distance. That is, the comparison of their actual (absolute)

(*Continued on Page 220*)

THE SMALL MAGELLANIC CLOUD AND TWO GLOBULAR CLUSTERS

The distance of the cloud, more than 60,000 light years, (that is more than 3.5×10^{17} miles), was determined by the study of its Cepheid variable stars. The brighter globular cluster is much nearer, but its light requires about two hundred centuries for the trip to the earth.

THE HYDRAULIC DRAFT TUBE

By WEBSTER K. RAMSEY, '22

One of the most important parts of an hydraulic turbine installation is the draft-tube. It is by means of this device that the turbine-runner may be placed at a considerable distance above the tail-water level, thus giving accessibility, and still lose but a small portion of the total available head.

The characteristics of this country require low-head turbines for the most part. Such installations require that the turbine runner shall be but a short distance above the maximum high water level for reasons of construction. The problem confronting the engineer in such cases is to design a draft-tube which will not only regain the head lost by placing the runner above the tail-water but also turn the discharged water through a right-angle bend in as short a space as possible. The problem of fulfilling the above requirements necessitates a knowledge of the action of the water under ordinary conditions which will be briefly explained herein.

Consider a sixty-inch turbine runner discharging vertically downward through a steel tube ten feet long. The tube, projecting into the tail-water about two feet, gives a total draft head of about eight feet; that is, the runner is about eight feet above the tail-water level. When the runner is operating at best efficiency, the water is discharging down the tube in fairly straight stream-lines. Under such conditions, the weight of the column of water from the tail-water level to the centerline of the runner, creates a vacuum directly under the runner which is very nearly equal to the eight-foot head seemingly lost by placing the turbine above the tail-water level. Unfortunately, variations in load on the generator seldom allow the turbine to operate at best gate for any length of time. Hence, conditions when operating at other than best gate must be considered.

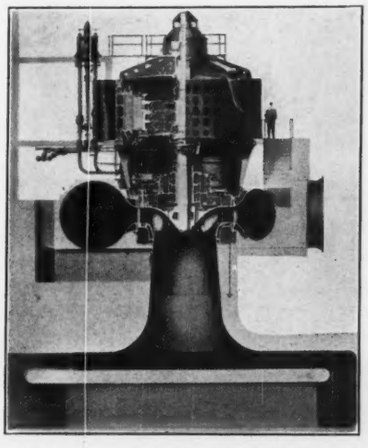
Assuming the same installation, it has been found that when the runner is operating above or below best gate, the water is discharging down the tube whirling at high velocity. At overgate, the water whirls in the same direction as the rotation of the runner; under best gate, the water whirls in the opposite direction. Either increasing the overgate or closing the gates from best gate increases the velocity of the whirling water discharged from the runner. The centrifugal action of the water thus whirling down the tube causes a column of water to be drawn up the central area to the bottom of the runner, whence the column turns outward and is discharged down the tube. The presence of this circulating column of water increases friction losses and reduces the vacuum under the runner which would otherwise be obtained.

Turning now to a conventional design used a great deal throughout the country, consider that the same turbine is fitted with a ninety-degree elbow tube, thus accomplishing the ninety-degree turn which was previously referred to as a draft-tube requirement. This design is seen to be inefficient at all gates for the following reasons:—

Granting that the turbine discharges the water in straight stream-lines at best gate, it is evident that the particle of wa-er turning the short radius of the bend is moving at a different velocity than the particle turning the long radius. Thus, there is an eddy-loss,—a sliding of one particle upon another,—across the section at the elbow in this form of tube. The losses at the lower gates are even more evident.

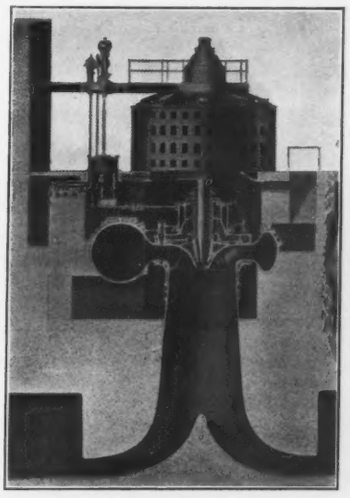
Consider now that the water is whirling violently downward from the runner. This rotating mass of water possesses properties not unlike those of the rotating wheel of a gyroscope, and like a gyroscope, it tends to keep in a plane perpendicular to its initial axis. Hence, it is evident that the water will not continue to rotate in a plane perpendicular to the axis of the draft-tube upon reaching the bend in the tube. There is a very considerable commotion at the bend of such tubes which causes a suction action at the end of the flare. This may be substantiated by noting that on such installations part of the discharge area is drawing water from the tail-race.

Water discharging from a reaction tur-



THE WHITE "HYDRAUCONE" TUBE
The man by the generator gives an idea of the size.

bine represents two forms of energy: static-head or pressure-head Hs, which is the energy due to pressure; and velocity-head Hv, which is energy of the water due to its velocity. At the discharge side of the runner, Hv+Hs=total draft head H, very nearly. Now when the turbine is operated at any but best gate, and even at best gate to a lesser degree, there is a high exit velocity to the water. This is especially true in the case of low-head, high specific-speed turbines. If the water is allowed to rush out of the draft-tube, much energy will be lost in the form of velocity or Hv. Hence, in each of the before-mentioned cases, the tubes are of increasing cross-



THE MOODY DRAFT TUBE
This picture is drawn to the same scale as the other one.

sectional area and therefore are supposed to gradually reduce the velocity of the water according to the principle of Bernouilli's theorem. Thus, since it is the static-head which is reduced on the discharge side of the turbine, if the Hv is reduced, the Hs will approach the total head, assuming the total head H to remain constant.

One of the prime requisites for the proper and efficient regaining of the static-head from velocity-head is that the water must be flowing in parallel stream-lines. It is obvious that with the exception of the first case concerning the short straight tube, the water is not moving in such a condition at any point.

The realization of the presence of wasted energy in such tubes as the foregoing led Mr. W. M. White of the Allis-Chalmers Mfg. Co., and Mr. L. F. Moody of the I. P. Morris Co., to make many experiments and designs in an attempt to produce a tube which would not only regain the static-head from the velocity of whirl, but also turn the water through a ninety-degree angle with as little loss as possible. The two designs will be briefly described.

Mr. White observed that when a jet of water was allowed to impinge at right angles on a flat plate, the water was not

(*Continued on Page 226*)

THE WATER POWER OF CANADA

By PROF. HAROLD K. BARROWS, '95

Associate Professor of Hydraulic Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

The growth of central stations in Canada has been very rapid in recent years and a network of transmission systems, which is being rapidly extended from year to year, covers Central and Southwestern Ontario and Southern Quebec, and smaller systems are also in progress at various points from coast to coast. Over 91% of the primary power used in central stations is derived from water.

The total capital invested in central stations, inclusive of transmission and distribution systems, is over $369,000,000, or an average of $210 per installed primary horse-power. Data of actual cost of construction of some seventy representative hydro-electric power stations, exclusive of transmission and distribution systems, show an average cost of $69 per installed horse-power, reflecting the general advantage of water power sites in Canada and consequent low cost of development.

Canada is well in advance in water power development as regards population, there being about 274 HP. per 1000 population, this figure being only surpassed by Norway, with about 487 HP. per 1000, and followed by Switzerland with about 137 HP. per 1000. It is interesting to note, by way of comparison, that in the United States there is at present about 8 million horse-power of developed water power, or about 73 HP. per 1000 of population.

The development and potential resources of water power per square mile of area, for some of the leading countries, is about as follows:

Country	Water Power in H. P. per sq. mile of Area	
	Developed	Undeveloped
Canada	0.5	4.8
United States	2.3	9.3
Switzerland	32.	125.
Norway	9.0	44.
Italy	10.7	44.

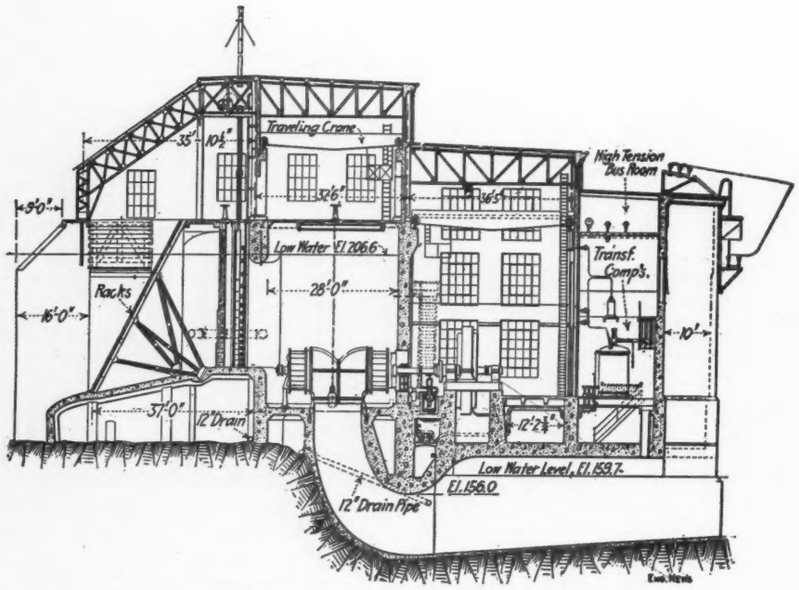
One of the most interesting Canadian provinces with regard to water power is that of Manitoba, in which is located the Winnipeg River,—a splendid power stream with flow kept very uniform by the magnificent natural storage afforded by the Lake of the Woods. This river drains an area of some 53,000 square miles and is one of the important power streams of the continent. The careful power investigations made by the Dominion Water Power Branch in 1915 indicated that over 420,000 HP. could be developed on Winnipeg River at very low cost and within easy transmission distance of Winnipeg.

There have recently become available the results of a careful census and analysis of water power in Canada pepared by the Water Power Branch of the Dominion, in co-operation with the Bureau of Statistics. Figures are available up to January 1, 1920, and indicate in a striking manner the extent to which water power is being used. Practically every industrial center in Canada is now served with hydro-electric energy and has within easy transmission distance large reserves of potential water power.
—Editor

Another noteworthy feature on this river is the municipal hydro-electric plant of the city of Winnipeg, which has been in successful use since 1911, affording light and power at low rates (now 3 1/3c per k.w.hr. for domestic lighting, as compared with 20c per k.w.hr. in 1906). This plant has recently been increased in size and now has a capacity of 70,000 HP. and has been an important factor in the development of this busy city at the gateway to the Canadian Northwest.

The water power developments at Niagara all told constitute the largest in the world, aggregating at present nearly 900,000 HP., of which some 500,000 HP. is in Canada. The new Chippewa development of the Hydro Electric Commission of Ontario, nearly completed, is also unique in that the entire fall at Niagara, including that in the Whirlpool Rapids and totalling about 305 ft., will be developed, by means of single runner 55,000 HP. units—the most powerful water wheels that have ever been built.

The comprehensive development of water power in Canada is in general on a more definite basis than in the United States as so much of the water power is controlled by the Government. This control is direct in the case of Manitoba and the provinces westerly thereof and vested with the provincial authorities (who co-operate with the central government in work of investigation) in the balance of the Dominion. New developments are to be carried out along the lines of careful plans prepared by the Water Power Branch and the power developed under long time license. Studies in detail have been made of practically all of the important water powers in Canada by the Water Power Branch and all new developments must be consistent with their plans, thus assuring a logical and eventually a complete development, as far as practicable, of all power streams.



CITY OF WINNIPEG,—SECTION THROUGH POWER HOUSE

We learn from a current issue of "Power" that the Maxim Silencer Company, of which Hiram Percy Maxim '86 is the President, has been developing a silencer for power plants, applications of which have already been made on oil and gas engines, compressed air on motors and several other similar devices.

The Sun's Heat.—After recent study, the United States Weather Bureau declares that the heat radiated from the sun does not fluctuate from day to day, although there may be small changes occurring over a long period of time. In its annual report, the Bureau states that the irregularities from day to day, which have been noticed in the past, have been due to errors of observation caused chiefly by the influence of the atmosphere on the incoming radiation. At the outer limits of the earth's atmosphere, the observers find, the differences from day to day are not more than two or three tenths of 1 per cent.

MANUFACTURE OF SEAMLESS TUBING

By JESSE F. HAWKES, '12

Superintendent, Baltimore Tube Co., Baltimore, Md.

Seamless brass and copper tubing combine the valuable properties of high tensile strength, pliability and resistance to corrosion, and in certain lines of industries these are of the utmost value. Because of these properties brass and copper tubing finds special application in the manufacture of sugar, alcohol, glue, and tanning extracts. In shipbuilding it is used both for condensers and general piping, while in the better grade of building construction, brass pipe is demanded. Large quantities are consumed in manufacturing gas water heaters, while in the automobile, tubing finds its way into many accessories and small parts. There are many other uses for tubing, but the preceding list will serve to show the important part that tubing plays in industry.

Broadly speaking, and neglecting certain refinements peculiar to individual plants, there are three approved methods of manufacturing tubing, namely, The Sand Core Process, The Mannessman Process, and The Blanking Process. As there are many steps in common between these methods, the first will be described completely and later it will be shown wherein the other methods differ from the first.

In making tubing by the Sand Core Process, there are five distinct stages of manufacture from the time the ingot metal is received up to the time the finished product is ready to be boxed for shipment.

1. Weighing metal for the alloy desired.
2. Casting.
3. Cleaning Casting.
4. Cold Drawing.
   a. Annealing.
   b. Pickling.
5. Finishing.
   a. Tempering.
   b. Inspection.
   c. Testing.

The metal comes to the mill in the form of ingots as they are cast at the refineries. The ingots, together with such scrap as seems desirable, are weighed up in the proper proportions to give the alloy or metal desired. Two common alloys of brass are Muntz Metal, 60% copper and 40% zinc, and Admiralty, 70% copper, 29% zinc and 1% tin. The possible alloys are numberless, but as the methods of handling them are practically identical, no detail is necessary here.

After the metal has been carefully weighed it is sent to the casters. The metal is melted either in an electric furnace, of which there are several approved types in use, or in small crucibles, fired either by coal or coke. For copper the entire charge is melted at one time, while for brass the zinc, or spelter, as it is commercially known, is added after the copper is melted. This is done to minimize the loss of zinc by oxidization. The molten metal is poured into a vertical cylindrical mould, in the center of which is fixed a sand core that can be removed after the metal is cold, thus giving as a finished casting a more or less crude seamless tube or shell, as it is called.

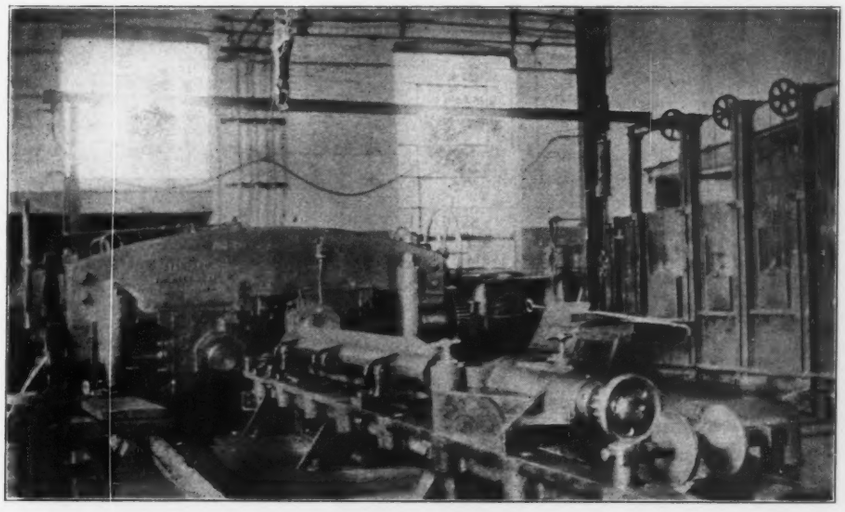
When the casting comes from the mould its surface is often very dirty. At this stage, before subjecting it to further operation, both the outside and the inside of the casting should be thoroughly cleaned. This may be accomplished in an acid bath, or by brushing out, or by any suitable method that will insure removing all scale and dirt from the surface.

The shell is now sent to the draw-benches, and by a series of operations is gradually brought to the exact size desired. The drawing is entirely a cold working process, with alternate cleaning and annealing. These operations may be performed either on a chain or hydraulic draw bench, which are identical in so far as the principles involved are concerned.

Stripped of detail, the draw-bench consists of a machine by means of which this rough tube can be shrunk through a steel die, while a steel plug or mandrel supports the inside. On each operation the size of the die and plug are so proportioned that the outside of the tube is reduced in diameter more than the inside, in other words the tube is made smaller and the wall thinner. Each working stresses the metal beyond the elastic limit, but not up to the breaking point.

It is obvious that if the metal is stressed beyond the elastic limit, future working will be impossible until re-crystallization has been effected by annealing. After each drawing operation, therefore, the metal is transferred to a large furnace and heated to a temperature such that re-crystallization takes place. The metal, after cooling and being cleaned of scale by dipping it in an acid bath, is soft and ductile again, and the drawing operations are continued until the tube has reached the size desired.

After the tube has been sized to the proper outside and inside diameters, it is ready to be given a few finishing touches to make it suitable for the purpose for which it is intended. The specified temper is secured by heat treatment in an annealing furnace, after which the tubing is straightened and cut to the proper length. As in all processes, the finished product is inspected and defective material culled out. Tubing to be used under pressure should be subjected to a pressure test to detect any defects that have escaped the inspectors.



DRAW BENCH

This machine draws the tube by successive stages to the desired diameter.

Returning now to the Mannessman Process, differences from the Sand Core Process will be found only in the stages previous to the cold drawing.

In the Mannessman Process the molten metal is cast in a cylindrical mold without a core, producing as a result a solid bar. These bars are brought to a red heat and are then run through the Mannessman machine, transforming them into crude seamless tubes while still hot. The operation is called "Pierc-

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PROFESSOR EDWARD FURBER MILLER

By PROF. C. E. FULLER, '92

Professor of Theoretical and Applied Mechanics, Massachusetts Institute of Technology

One of the most widely known members of the instructing staff of the Massachusetts Institute of Technology, among its students and alumni and in the engineering world at large, is Professor Edward F. Miller, head of the Department of Mechanical Engineering, at the present time a member of the Administrative Committee and the Chairman of the Faculty. He has been connected with the instructing staff for over thirty-five years, starting as an Assistant in Mechanical Engineering the year following his graduation with the class of 1886.

He was born in Somerville in 1866 and received the larger part of his early education in the public schools of Cambridge. He prepared for entering the Institute at the Cambridge High School and was admitted in the fall of the year 1882. In those days a large portion of the site on which the Institute buildings now stand was a marsh, the Cambridge side of the Back Bay not having been filled in, and at high tide the water extended as far back as Sidney street and Front street, a street a short distance to the south of and parallel to Main street. The track of the Boston and Albany Railroad running back of the Institute power house, at that time was carried across the marsh land on piles. A point of land, known as Whittemore's Point, extending out into the bay in the vicinity of the site of Building 1 of the Institute, was, at high tide, very popular among the boys of Cambridge as a swimming resort.

EDWARD FURBER MILLER

The story of Professor Miller's work at the Institute since his graduation with the class of 1886 is closely linked with the story of the growth of the institution, particularly of the Mechanical Engineering Department. At the time of his promotion to an Instructor in Mechanical Engineering in 1888, plans had been made, under President Walker's direction, for a new building on Trinity Place. This building, afterwards known as Engineer-Building A, was completed and occupied by the Mechanical and Civil Engineering Departments in the year 1889. The Mechanical Engineering Laboratories, located on the first two floors of the building, were at that time considered among the finest in the country. In 1892 Professor Miller, who had previously been engaged in more or less general instruction in Mechanical Engineering, including drawing room and design work, was made Assistant Professor of Steam Engineering and placed in charge of this Laboratory.

Previous to this, in the summer of 1889, he went abroad, in company with Professor Schwab, with the American Society of Mechanical Engineers, who were entertained as guests by the French and English Mechanical Engineering Societies. After the final meetings were over he visited, with Professor Schwab, a number of technical schools and industrial establishments in Germany. During the trip they were given the special privilege of visiting the Krupp Works at Essen, and on this visit they were entertained and shown through the different branches of the establishment by Herr Zeuner, a nephew of Zeuner of thermodynamic fame. They made similar visits in England and during their stay were entertained by the officers of one of the British torpedo boat destroyers.

As the Institute grew, additional buildings were put up, first Engineering Building B, then the Henry L. Pierce Building. These were followed by a building for the Department of Naval Architecture and the buildings for the Electrical Engineering Department. As these buildings were added, the quarters of the Mechanical Engineering Department were extended also, and the laboratories expanded until they occupied the whole of the basement of Engineering B and Pierce Buildings. With the construction of each new building it became necessary to add to the Power Plant, from which the heating and lighting was supplied. Under Professor Lanza, who was the Head of the Department of Mechanical Engineering, Professor Miller had a large part in planning these extensions to the Laboratories and Power Plant and supervised personally the installation of new apparatus and additions to the plant.

Meanwhile in 1899 he had been promoted to an Associate Professorship in Steam Engineering and six years later, in 1905, was made Professor of Steam Engineering.

As Instructor and Professor of Steam Engineering he made a specialty of boiler design and the operation and design of steam power plants, and soon came to be recognized as an authority on these subjects. The text book on "Steam Boilers," the first edition of which was written with Professor Peabody as co-author, was published in 1897. This book, revised by Professor Miller several times since, is recognized as one of the leading text books on the subject.

His study of boiler explosions, their causes and effects, has led to his being sought as an expert in many legal cases and a very interesting article might be written on his experiences in the courtroom if facts necessarily more or less confidential could be disclosed. His success as an expert, and it is said that no lawyer ever mixed him up on cross-examination, is no doubt largely due to his straightforward purpose in every case, to get the true facts, no matter to what conclusion they might lead.

In 1904 he was commissioned by President Prichett to make a trip to Europe for the purpose of studying the instruction in engineering in foreign technical schools. He visited a large number of schools in England, France and Germany and, on his return, made a report to the Corporation of the Institute on the methods of teaching and laboratory practice which might be of value in the development of courses at the Institute. Later, the more salient features brought out in this report were embodied in the work here.

On the retirement of Professor Lanza as Professor Emeritus in 1911, Professor Miller was made Acting Head of the Department of Mechanical Engineering and the following year was appointed Head of the Department. At this time plans for the new Institute buildings in Cambridge were being developed and at the request of Dr. Maclaurin, President of the Institute, tentative plans for laboratories, drawing rooms and lecture rooms for the Mechanical Engineering Department were drawn up under Professor Miller's supervision. Various studies, extending over a period of more than two years, were made: and the plans of the Mechanical Engineering Laboratories, Machine Tool Laboratories, Foundry, Carpenter Shop and Forge Shop, as well as the Mechanical Engineering Drawing Rooms, which were finally installed in the new buildings at Cambridge, were largely the result of Professor Miller's efforts. During the erection of the new buildings, at the direction of President Maclaurin, he was given supervision of the installation of all the laboratory apparatus in the Mechanical Engineering Department and it may be added that not the least of the results of his unrelenting efforts, during the two years in which the buildings were under construction, was the installation of the excellent system of lighting in the present third and fourth year Mechanical Engineering drawing rooms. To obtain this system in place of a cheaper, and inferior system, Professor Miller was obliged to make a long, strenuous effort which culminated in presenting his case to the President and members of the Corporation, who became convinced of its merits and ordered the system installed. The plant of the Mechanical Engineering Department, generally acknowledged to be the finest of its kind in the world, is perhaps Professor Miller's greatest achievement.

After the death of Dr. Maclaurin in January, 1920, Professor Miller was appointed as one of the Faculty members of the Administrative Committee to take charge of the administration of the Institute until a new President was chosen. He has served continuously on that committee up to the present time, devoting unreservedly of his time and efforts to the work of the committee. Last spring he was elected to the Chairmanship of the Institute Faculty, which office he now holds.

Professor Miller has been a member of the A. S. M. E. since 1891 and a member of the American Society of Civil Engineers since 1903; he is a member of the Boston Society of Civil Engineers; a member of the American Society of Refrigerating Engineers and has been a member of the Engineers' Club of Boston since it was founded. He is a member of the American Academy of Arts and Sciences, a member of the University Club, and a life member of the Massachusetts Charitable Mechanics Association. He is also an honorary member of the National Association of Stationary Engineers, this membership having been conferred upon him in appreciation of lectures and educational work among a number of different organizations of this association, to which he had devoted a large amount of time and effort. He has served on a number of different committees of the American Society of Mechanical Engineers, having been a member of the Boiler Code Committee of that Society ever since the committee was started. He is also a member of the Main Committee of the A. S. M. E. on Power Test Codes and a member of the individual committee on Refrigerating Machines and Plants. As a member of the A. S. M. E. Research Committee on Safety Valves, Professor Miller made an exhaustive study of the operation of these valves, including an extensive series of tests on the relieving capacity of safety valves under pressures ranging from 50 pounds to 250 pounds per square inch. The results of his investigations were first published in pamphlet form by the Crosby Steam Gage & Valve Co. of Boston and later were embodied in the Transactions of the A. S. M. E. He has been Director and Vice President of the American Society of Refrigerating Engineers and is a member of the Committee on Refrigeration Regulations.

When the State of Massachusetts appointed a commission to draw up a set of rules governing the construction of steam boilers which were later embodied in the laws of the Commonwealth, Professor Miller was appointed as an advisor to the commission and acted continuously in that capacity until the work was completed.

As an exemplification of his aim to always keep in touch with the practical side of engineering as well as the theoretical, he holds a first-class unlimited stationary engineer's license, which he obtained by taking the regular examinations of the State of Massachusetts for engineers of this class in 1897.

In addition to the publications already mentioned Professor Miller has written many articles for different Engineering magazines as well as notes on Power Plant Design and on Heating and Ventilation for the use of students at the Institute.

Soon after the United States entered the World War in 1917 the United States Shipping Board realized that if the ships under construction were to be properly manned, a large number of engineer and deck officers must be trained. Mr. Henry Howard, who had been appointed by the Shipping Board to direct the recruiting of these officers, appointed Professor Miller in June, 1917, to have sole charge of the establishment and direction of a series of schools in different parts of the country for the purpose of giving engineer officers the necessary fundamental training to enable them to operate the engine rooms of the ships; first as subordinates and afterwards as assistant and chief engineers, as soon as the necessary sea experience could be gained. Under Professor Miller's direction thirteen different schools were established, including the one at the Massachusetts Institute of Technology, the others being located in New York, Brooklyn, Jersey City, Hoboken, Chicago, Cleveland, Philadelphia, Seattle, New Orleans, Baltimore, and Berkeley, Cal. At the time of the armistice about 2000 men had received instruction in these different schools and a large majority of these men were commissioned as engineer officers in the United States Merchant Marine.

Besides directing these schools, which necessitated taking care of a large amount of correspondence and a number of personal visits to different parts of the country, Professor Miller himself gave a series of lectures in the school at Technology and wrote three sets of notes in pamphlet form for the use of officers who were being trained. At the close of the war the original series of schools was superseded by schools at the Institute of Technology, Brooklyn Polytechnic Institute, Tulane University, New Orleans, and at the University of Washington, Seattle, for advanced training in turbine engineering for which licensed engineer officers were eligible. Professor Miller had full direction of these schools until his resignation, Sept. 15, 1921.

During the war, in addition to his work for the Shipping Board, Professor Miller was engaged in confidential work for the United States Army, first under General John A. Johnston, Commandant of the Department of the Northeast, and General Black, Chief of Engineers. He continued this work under Generals Crozier and Ruckman, who succeeded General Johnston in command of the Northeastern Department, up to the close of the war.

Since the war, mainly through Professor Miller's efforts, a Reserve Officers'

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WAR FLYING

By HOWARD F. RUSSELL, '22

Airplanes are one of the modern instruments for waging war. They are of immense value both to armies and to navies. The different kinds of war flying found necessary to an army by the United States and the Allies may be classed as follows; pursuit or chasse, observation, light bombing, heavy bombing, and night chasse. Each class requires a special design of airplane and a different kind of advanced training for the pilots and the crew.

It is the ambition of every aviator undergoing preliminary training to become a chasse pilot, for they have the best chances to become aces. It is the duty of chasse planes to protect formations of friendly bombers when they make excursions against the enemy and to seek out and destroy enemy aircraft whether they are other chasse planes, bombers, or stationary observation balloons. In all this work it is necessary to have a very fast ship and one that can maneuver quickly. Therefore only the smallest ships with a high ratio of horsepower to wing area can be used. These ships must have a very high "ceiling" for in a "dog-fight" the advantage rests with the plane that started at the higher level irrespective of the altitude at which the fight takes place. At the end of the war the British had developed for chasse work the Camel, S. E. 5, and the Snipe; the French had the Spad and the Nieuport 28; and the Germans had the Fokker 7. The Americans had no chasse planes of their own make overseas.

The armament of these ships consists of two very rapid fire machine guns permanently fixed in one position on the ship and synchronized to shoot between the blades of the revolving propeller. Armor-piercing, incendiary, and tracer bullets were used in these guns besides the ordinary service ammunition. Usually the belts were loaded with a mixture of all four kinds to suit the particular purpose the pilot had in view.

CHASSE PLANE

This type of plane was used in France for breaking up bombing formations and for pursuit work.

In attacking an enemy formation the desired position is above it and if possible between it and the sun. From this position any sort of an attack can be launched against any enemy formation. Chasse planes can be attacked from any position except directly in front of them, the favorite spot being from above and from the rear. But two-seater observation or bombing planes require different treatment. The only spot their defensive guns cannot shoot at is underneath. Hence, when attacking two-seater planes, a chasse plane dives under them and with the increased speed gained from the dive quickly attacks from underneath. If the first burst of shots fails a good pilot can, by proper maneuvering, keep under the blind spot and attack again. Some of the largest bombing planes mount a pair of machine guns so that they will shoot to the rear from the under side of the plane. One of the first German planes thus equipped accounted for the American ace, Lufberry, who, believing it to be a two-seater machine, flew directly in front of these guns. These three-seater planes have no blind spots so the attacking pilot trusts that by quick maneuvering and by the use of his own guns, he will be able to rattle the enemy gunner and prevent him from shooting accurately.

It has been said that the Air Service during the war was ninety per cent air and ten per cent service. However, be that as it may, it is certain that commercial aviation owes its present state of high development to the lessons learned by "war flying." These lessons, learned by bitter experience, have been adapted to "peace flying" with the result that we now see several transportation lines, functioning daily with no loss of life, and a regularity which puts to shame, many railroad schedules. Aviation is without doubt, the transportation of the future, and is a field which offers unlimited possibilities to the engineer, in actually designing planes, developing direction-finding apparatus, and solving problems incident to night flying and night landing. This essay is one written for the Boit Prize and received high commendation at the hands of the examiners.—Editor.

Because of the small size of the ships the ideal chasse pilot is not very large but has the ability to think and act quickly. Also he must have a total disregard for his own personal safety.

Observation is one of the most important uses of aircraft in war. These ships are medium sized, single motored, two-seater machines, equipped with four machine guns, flares, a wireless outfit, and a camera. At the time of the armistice the British and the Americans were using the De Haviland; and the French, the Salmsons and the Breguets.

From the reports and photographs obtained by these planes the army headquarters is better able to strengthen the defences and plan the attacks. Formations of these ships, with or without chasse protection, make excursions far behind the enemy lines noting and making photographs of trenches, gun emplacements, ammunition dumps, activities on the roads and railroads, concentrations of troops or supplies, and any other information about the enemy. During an attack they fly low over the trenches and give troops valuable assistance in overcoming machine gun nests and shooting up opposing troops. They also locate advance troops and often give headquarters valuable information concerning troops that are temporarily beyond communication. When working with a battery of artillery they locate the targets, observe the falling of the shots, and send back corrections for them. During the war wireless alone was used for this work except when the enemy succeeded in disturbing or crowding out the weak apparatus that is used on airplanes. At these times the plane flew back to the battery and dropped a written message. Why the wireless telephone was not used in France is a mystery. There were a sufficient number of pilots in France before the armistice who had been trained to use this new apparatus and who had found it very satisfactory.

Light bombing and observation are the only two kinds of flying that can use the same types of planes. The pilots and observers are frequently trained in both kinds of work. The ships are usually equipped with both bomb racks and observation apparatus so that they can be used for the type of flying there is the larger need of. Light bombing is chiefly directed against troops on the ground, gun emplacements, supplies, ammunition dumps, railroad stations, and other places of importance back of the enemy's lines. The explosive bombs used are stream-line steel shells containing large amounts of high explosive. They very seldom use any bombs in this work that weigh over one hundred pounds. All bombs are designed to explode by contact. Those that are directed against buildings are equipped with a fuse that gives delayed action, so that when it strikes a building it will pass through the roof and floors and explode in the cellar. The incendiary bombs weigh about thirty pounds and are largely composed of pitch-blend or some other highly inflammable material. Towards the end of the war the English brought out a thermite bomb weighing about two pounds. They produce a very intense flame and because of their light weight a larger number can be carried and distributed over a greater area. Light bombing was carried out both by day and by night.

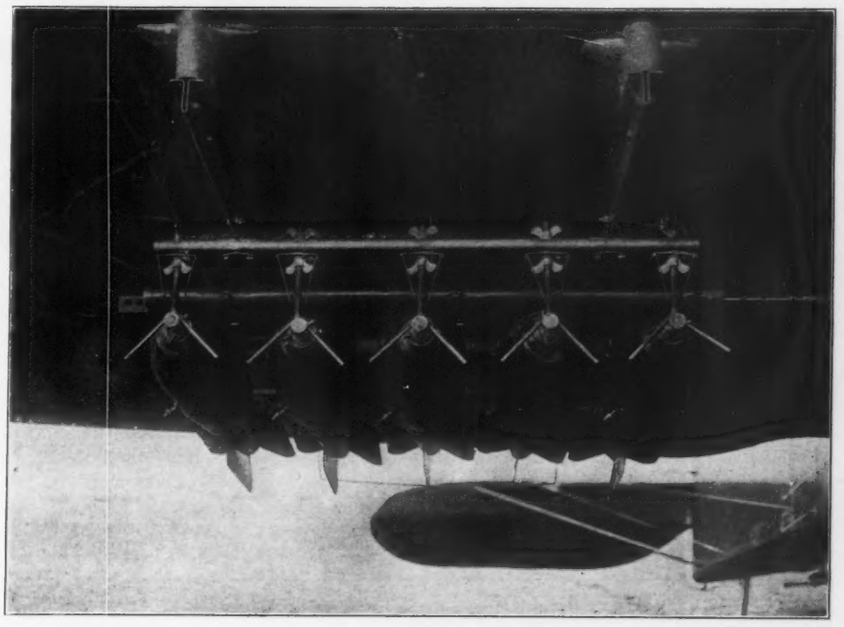
For heavy bombing very large ships

were used. The English used the Handley-Page; the Germans, the Gotha; and the Italians, the Caproni. These ships had as many as six engines and sometimes carried a crew of six men. One Gotha that was shot down by the British was estimated to have weighed eight tons without its load of men and bombs. These huge machines usually operate at night when they can not be easily seen. Because of their size and inability to maneuver they are comparatively easy targets for anti-aircraft guns and enemy chasse planes. They operate against enemy supply or ammunition dumps, important railway junctions, and, whenever possible, against munition factories or gas producing plants. During the war they carried bombs weighing up to 800 pounds but since then bombs weighing over 2000 pounds have been developed and successfully used.

As an aid to accuracy in dropping bombs at night parachute flares were developed and used in many attacks. They produce an intense light as they slowly float towards the earth and light up the surrounding country sufficiently to allow the bombers to choose their targets. Since the war they have been developed to such an extent that now they produce a light of several million candle-power.

Night chasse flying was used during the war as a protective measure only and then only around cities that were most often the targets for the enemy's bombs. They used the same small ships that were used for day-time chasse flying. These ships were held in readiness near a city and when notice came that enemy bombers were approaching they would take to the air and endeavor to shoot the enemy down before he could deliver his bombs. It was extremely dangerous work flying around in the dark looking for an object a shade darker than the night itself and never knowing when one might meet a friend going in the opposite direction.

Landing a ship is always the hardest part of flying and is extremely hazardous after dark. All manner of devices have been tried to help the pilot make a good landing. An airplane lands at a speed up to seventy-five miles an hour and sometimes even faster so that a considerable amount of ground must be illuminated if any help is to be given to the pilot. Lights on the airplane itself are practically useless. Parachute flares are some help in a forced landing provided the pilot has several of them and plenty of altitude to start with. The home field of a night flying squadron can always be illuminated and does give the pilot some idea of where the ground is. But even this has its disadvantages. The story is told about an English squadron that listened with considerable interest as German bombers passed over their airdrome every night bound for a city back of the lines. This did not happen many nights before the English could tell the Germans' destination and probable time of return. They already knew where their home airdrome was, so one night the English squadron took to the air, went over to the German airdrome, and circled around until the returning Germans appeared with their gasoline tanks and bomb racks empty. The Germans on the ground knew the English were above them but had no way of notifying their own ships. They had to light the field because the returning ships would be out of gas. The German pilots had no choice, they had to land somewhere. As fast as they appeared in the square of light the English shot them up. Night bombing ceased to be a pastime along that part of the front.



READY FOR ACTION

This shows the bombs slung under the lower plane ready to be released

Flying for the navy may be divided into the following classes: observation, light bombing, and heavy bombing. Chasse flying for the navy was not undertaken to any great extent during the war but it doubtless will become necessary when airplane carriers accompany each fleet.

The importance of observing for a fleet of battleships cannot be overestimated. An airplane at a height of 500 feet can see the surrounding ocean for 50 miles on a clear day. With a cruising speed of 120 miles per hour for four hours they can do the fleet reconnoitering much quicker and cheaper than a flotilla of destroyers. Of course airplanes will never displace destroyers for destroyers have other uses besides scouting.

Nearly all airplanes that have been launched from the decks of battleships have been single-seater, land machines and they cannot land on a battleship. Once launched they must cut short their period of usefulness in order to make for land or else land on the water and become a total loss. If seaplanes are used they need a comparatively smooth sea in order to make a good landing. To be of maximum usefulness an observation plane should carry an observer besides the pilot. Then they can report by wireless all observations concerning the enemy and the spotting of shots for the big guns. Airplanes can be landed on the deck of a specially designed airplane carrying ship. These ships can be equipped with gyroscopic anti-rolling devices so that they provide a smooth landing platform except in the very roughest weather. Provided with such vessels airplanes can accompany a battle fleet anywhere on the ocean and can, in all but very stormy weather, furnish the commanding admiral with the information so necessary in order to plan his line of battle. Admiral Beatty was greatly handicapped at the battle of Jutland by not knowing the exact position of the enemy. Because he realized that the safety of the Empire depended on the Grand Fleet he had to play a conservative game and make sure that the High Seas Fleet did not gain a superiority of strength.

Light bombing for the navy is carried on by single or double motored airplanes and seaplanes carrying bombs weighing up to 400 pounds. They are especially effectual against submarines and are a menace to larger craft. Filled with explosive they will sink a submarine if

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THE MANUFACTURE OF PHOTO LENSES

By FREDERICK L. HIGGINS, '04

Manager, Hawk-Eye Works, Eastman Kodak Co., Rochester, N. Y.

Photographic lenses may be divided into two groups; first, single meniscus and achromatic lenses; and second, anastigmat lenses. The methods employed in their manufacture vary according to the type of lens one wishes to make.

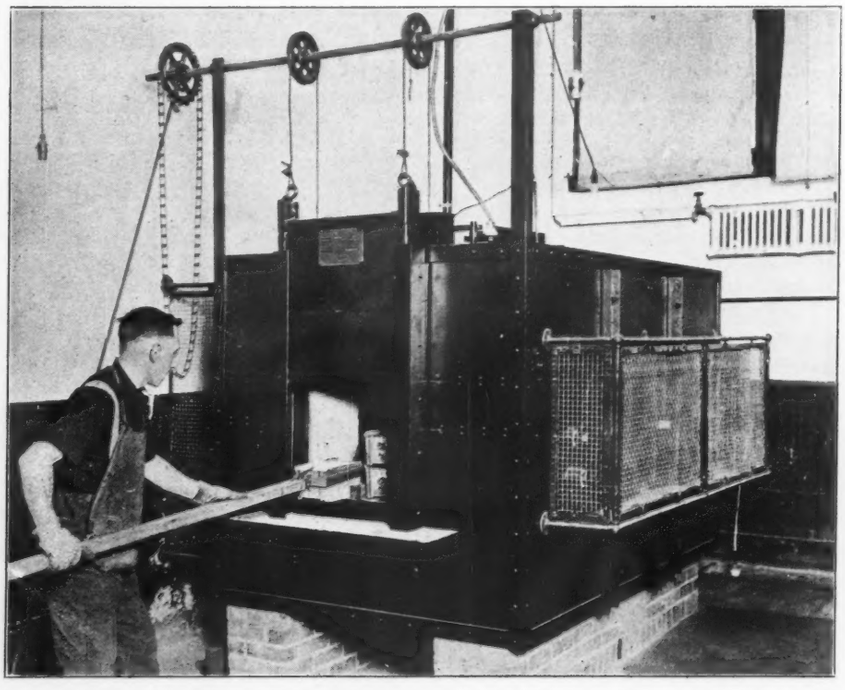
Anastigmat lenses represent the highest attainment in the optics of photography because of their wide covering power and their speed. They are corrected to eliminate such defects as astigmatism, coma, and distortion, and will cover with a flat field a photographic plate subtending an angle of fifty to seventy degrees. Due to their being corrected for such large apertures they can be used wide open, enabling one to make pictures at a speed of a thousandth of a second, and permitting snap shots to be made in dim light, a thing impossible with lenses of lower aperture.

The optical mathematician has at his disposal catalogues of the glass maker which list the various kinds of glass now available, and from his computations he determines the kinds of glass to use, the number of elements the lens shall have, and the curvature and thickness of each element. The glass is specified by name, and by the indices of refraction and dispersion. The mathematician has found that his problem of making a well corrected lens is best solved by dividing the work to be done by the lens among a number of refracting surfaces. Therefore, most anastigmats consist of several elements, the number varying from three to ten single lenses so chosen with respect to curves and glasses that they will reduce the residual aberration to a minimum. This article will deal with the production of only one type of lens, the Kodak Anastigmat of the f-7.7 series. This lens has four elements, two positive or collective lenses, and two negative or dispersive lenses. It is air-spaced, having a diaphragm across the central separation and is symmetrical in form.

LENSES BLOCKED AND READY FOR GRINDING

The lenses are fastened to the blocks with pitch.

Unwrought optical glass may be obtained in this country as well as from abroad. It is received in the form of slabs; the size depending on the purpose for which it is to be used. For Kodak Anastigmat f-7.7 lenses slabs approximately six inches square and one inch thick are of a convenient size. The glass is inspected at the glass plant for flaws, and tested to see if the optical properties are in accordance with specifications, and it is again subjected to a critical examination as soon as it is received in the lens factory. After examination it is sent to the cutting room where the slabs are sawed into strips and cubes by means of diamond impregnated saws.



ANNEALING OVEN WITH AUTOMATIC CONTROL

By keeping the glass in a plastic state for some time, all strains in it are removed.

The cubes are placed in gas furnaces and heated until the glass is plastic when they are removed and pressed into what are called discs or blanks. After being pressed, the discs are placed in an annealing oven, the heat of which is regulated by an automatic control. This control may be set at a predetermined temperature and the heat of the oven will rise to that temperature and hold it indefinitely with only slight variations. At this degree of heat whatever strain may be present in the discs will be gradually relaxed and by slowly cooling no new strains will be introduced. After annealing, the discs are passed through rays of polarized light and if no shadows are seen, denoting internal strains, they are forwarded to the roughing department. All discs showing strain are returned for re-annealing.

The discs are blocked on metal blocking bodies, hot pitch being used to hold them in place, and the surfaces are ground with various grades of emery ranging from 70 to 240 grains to the inch. The lenses are removed from the shells and the same operations are repeated in grinding the opposite side. When the lenses leave the roughing department they are all of the same thickness to within a hundredth of a milli-

meter. The next step is the application of a small button of pitch to each individual lens. It is by means of these pitch buttons that the lenses are held in place and that the uniform thickness already established is maintained during the grinding operations that follow.

The lenses are now blocked preparatory to fine grinding, the tools are placed on automatic machines, and the lens surfaces are ground until they are semi-transparent. They are then delivered on the same blocks to the polishing machines. The polishing operation is similar to the grinding except that rouge is used in place of emery and the polishing caps are lined with wax. The polishing is continued until the curvature is correct and the necessary degree of polish is obtained. In testing the accuracy of the curve a test glass (a lens of equal but opposite curvature) is applied to the polished surface and if the two curves differ by even a thousandth part of a millimeter the interference rings called "Newton Rings" will be present. The polishing is then continued with the proper adjustment of the machine and polishing cap until the rings disappear, when the curvature will be perfect. In removing lenses from the blocking bodies, especially if the lenses are thin, there is great danger of chipping the edges and so in order to reduce the amount of handling the blocking bodies are placed in a refrigerator where the lenses upon being chilled readily separate from the pitch.

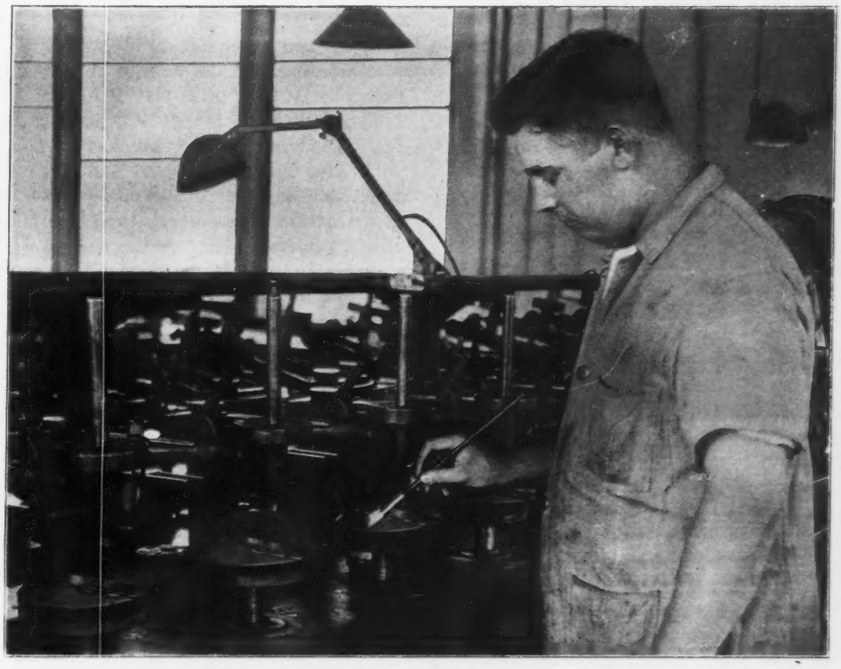
Each lens element is now cemented to the revolving chuck of a centering machine. In the chucking operation the lens must be located so that while it revolves there will be no motion to the images of an illuminated target reflected from its two surfaces. After the lens has been thus centered, it is trimmed to diameter and the edge is bevelled.

Mounting the lenses is an operation of first importance in an anastigmat of the air spaced type. The separations are very sensitive and play an important part in correcting the lens. Provision has to be made so that the depth of each air space between the lens elements may be altered as there are always slight variations of index in the glass itself as well as slight variations in the thicknesses of the finished lenses which have to be compensated for, and these are taken care of by altering the air spaces.

The brass mounts must be turned with great precision and be absolutely true, for if they are not, the lens will not form a satisfactory image, and all of the care exercised in making the lens components will have been so much wasted effort.

When the mounts have been japanned and engraved, the lenses are assembled in their proper order, one pair of elements (a flint and a crown) in each mount, and this combination is tested to see if it is properly centered. Two combinations are then assembled to a camera shutter and after a similar test for centering the completed lens is ready for final examination.

The completed anastigmat is now subjected to two tests; one a simple test for focus and definition, and the other a critical examination upon the Optical Lens Bench.



GRINDING AND POLISHING ANASTIGMAT LENSES
Rouge is used for the final polish.

WAR FLYING

(*Continued from Page 211*)

they strike near it. They will damage other craft to a considerable extent. Filled with gas they may cripple the crew of the entire ship or when filled with smoke-making material they may prevent the gunners from doing accurate shooting. This type of aircraft usually operates from land bases but will be able to operate from carriers after the latter have been more fully developed.

Heavy bombing is done by multiple-engined airplanes or seaplanes carrying a useful load as large as six tons. They carry bombs ranging in weight from 400 to 2000 pounds. One type of plane has been developed that successfully launches the heavy standard Whitehead torpedo. Needless to say these planes constitute a real menace to an enemy fleet. They have to operate from land bases but they form a defence that reaches out a hundred miles from shore. Recent tests have proven that they can cripple and destroy a modern battleship. As for displacing a battleship, that can hardly be expected. As long as nations continue to arm the battleships will rule the ocean.

The art of flying advanced more during the war than it would have in one hundred years of peace. In the next war both armies and navies will rely more than ever upon the assistance an air service can give them. It is to be hoped that our Congressmen in Washington will realize this and make provision for an adequate air service.

MONTHLY NEWS

Synthetic Coal.—Experiments carried on for more than six years by Ludwig Prueckner, a practicing chemist of Berlin, have led to the discovery of a synthetic coal. The composition of the coal is secret and patents on the process have been applied for. Prueckner gave a demonstration before a number of professors and chemical experts which convinced them of the importance and value of the discovery. Prueckner's synthetic coal develops 8,000 heat units and produces a gas equal to that obtained from the best coal, while the cost of production is about half the market price of ordinary coal at the present time.

The New Brennan Helicoptor, which was built secretly at a British aviation base, has completed a successful ascent. The machine, which has neither wings nor gas bags, but is able to rise and descend vertically by the rotation of air screws, was designed by Lieutenant Brennan, and is being tested by the British government at the Farnsborough aviation base. Details of construction are unknown but horizontal speed and direction control is secured by slight inclinations of the vertical axis of the screws and use of large rudders. Military men believe the helicoptor will be valuable in war for gun spotting and will take the place of the vulnerable fixed balloons.

Steel Saving Alloy.—The discovery of a new alloy by which low carbon or waste steel can be turned into the best tool steel was made in the experimental laboratory of the University of Delaware. The alloy costs very little but has the valuable property of increasing the tensile strength of steel to which it may be added.

Tokio Super-Power System.—The Westinghouse Electric International Company has received orders from the Daido Electric Company of Japan for electrical apparatus for two large hydro-electric plants which are to form a part of a super-power system in the Tokio district. The current is to be transmitted at 154,000 volts. The total value of this apparatus is about $2,000,000.

World's Longest Span.—The new suspension bridge connecting Detroit and Windsor will have the longest single span in the world, measuring 1802 feet, or 24 inches longer than the great cantilever at Quebec. The double deck bridge, which will connect United States and Canada, will accommodate street car, automobile and pedestrian traffic on the upper deck and passenger and freight train service on the lower deck. The construction work beginning next spring will occupy a period of six years. The upper deck should be ready for service within four years and then without interfering with traffic on upper deck the construction of the lower deck will require two years more.

The span, suspended from two towers each rising 380 feet above water level, will have a width of 97 feet for the highway deck with two trolley tracks, two sidewalks and two roadways, while the lower deck will have four railway tracks and a 20-foot space of public utilities equipment. Electric locomotives will be used on the lower deck.

Completion of the bridge means the doing away with train ferries across Detroit River. The bridge will be built by the Canadian Transit Company and the American Transit Company and will cost approximately thirty millions of dollars. Construction is expected to begin from the American side.

Acetylene as Motor Fuel.—The question of a substitute for oil as motive power for automobiles has been solved by Germany. Germany has no oil and with her currency in the present condition, cannot afford to purchase what she needs. This led to a discovery which may revolutionize the automotive industry. Acetylene gas, generated by the action of water on calcium carbide, is now used in Germany. The engine has been perfected and the gas is compressed and stored in cylinders. Today the automobile user stops at a station and instead of having his gasoline tank filled, exchanges his cylinder or has it recharged. Many stations for this purpose are being built in Germany.

New German Zeppelin for United States.—The Allied Council of Ambassadors has granted permission to the United States to contract for the construction of a zeppelin of the L-70 type at Friedrichshaven, Germany. The application for the zeppelin grew out of the destruction in Germany of five of the big dirigibles, one of which had been allotted to the United States during the peace conference. From nine months to a year is the time estimated by American engineers as required for building the huge ship, since Germany has all the necessary materials, including duralumin for girders. The plans specify that the new zeppelin shall be modeled after the L-70, -71, and -72. Each of the latter was of 2,400,000 cubic feet volume, a little larger than the navy's ZR-1 which is now being built at the Naval Aircraft Factory in Philadelphia.

The L-70 class of airship measured 743 feet in length, with a standard gas-bag diameter of 78.4 feet. Their total useful load is 88,000 pounds, equivalent to fifty-nine per cent of the total weight of the ship. The propulsion power was furnished by seven Mayback engines, four hundred horsepower each, developing a speed of eighty miles an hour. The crew carried was thirty men.

New Channel Completed.—The completion of the 12½-mile Chippewa-Queenston channel by the Ontario hydro-commission brings the total water power development at Niagara Falls to approximately 1,000,000 horse-power. Construction of this channel has been going on for three and a half years and in this time, dredges have removed 13,200,000 cubic yards of earth and 4,182,000 cubic yards of rock. This total is slightly more than the amount removed by the French from the Culebra before the United States undertook the completion of the Panama Canal. The maximum depth of the Chippewa channel is 145 feet and at one point a rock cut of 85 depth was made. Also it was necessary to reverse the course of the Chippewa creek from its natural southerly course to its present northerly direction. The cost of the Chippewa-Queenston canal is about $65,000,000, with an additional sum of $15,000,000 for the 10 unit electrical generating plants of 650,000 horse-power output. With the three present plants with total output of 450,000 horse-power the total of Canada's Niagara production rises above the 1,000,000 horse-power mark.

This remarkable development has been accomplished within the last quarter century for it was in 1895 that the first industry plant was run by hydro-electric energy. This power delevopment has been under government control and furnishes power over a wide field by serving municipalities within a radius of 200 miles with electric current for light, heat and power.

Italian Telephone Contract.—The Post and Telegraph Administration of Italy has closed contracts for the installation of an underground telephone system worth, at current rates of exchange, approximately $3,500,000. The new system will include all latest improvements of the Bill system and will link the cities of Genoa, Turin and Milan. The Italian tricity toll system when completed will rank as one of the most important underground systems of long distance communication on the other side of the Atlantic. The circuit will be slightly more than 130 miles long and in formation resembles the letter "Y," with the three branches converging in a centrally located point in the mountains of Northern Italy.

Guiding Wireless Waves.—A Ukrainian engineer is reported to have discovered a method by which wireless messages may be sent to a definite receiving station without the danger of being intercepted by other stations. It is stated that by means of a simple apparatus, the so-called "locked power lines" of the magnetic field may be straightened out and grouped into parallel rays. These rays are said to do away with the necessity of antennae.

The Biggest Waterway project ever undertaken in Europe—the construction of a canal connecting the Rhine, the Main and the Danube, to require twenty years for completion—has been undertaken by a newly organized German corporation. The canal is designed as a thoroughfare between the North and Black Seas with continental connections. The total length of waterway will be 3437 kilometers (2134.377 miles) and will accommodate 1500 ton ships. Part of the canal will be built across a 1200 foot elevation requiring sixty locks over a distance of 700 kilometers (437.7 miles). Forty power plants capable of developing 400,000 horsepower and designed to furnish 2,500,000,000 kilowatts of power per hour at an estimated saving of 3,000,000 marks worth of coal per year, will be erected along the canal.

Drawbridge Dam.—A remarkable engineering feat is nearing completion in the North Canal at Sault Ste. Marie, Mich., by the construction of a movable steel dam. The dam affords protection to two locks in the Soo Canal. The entire frame work of the dam, weighing approximately eighty tons, is being swung into place at one time by the means of a stiff leg derrick on either side of the canal. The new dam is considered by engineers as a new step in such construction as the entire frame work and gates are being built of steel. The dam will be operated much like a drawbridge, being divided in the middle. Either or both sides of the gates may be closed at a time, keeping the water from one or two locks, as desired.

Paper Piling.—A new pile is being made of paper in California. The pile is made by winding long rolls of tarred paper with glued edges on a long wooden cylinder and covering with cord. Over the first layer, another band of paper is wound diagonally like the bandage on a wounded arm. More cord and glue is applied and after three layers of paper are applied, the wood cylinder is removed and the paper cylinder reinforced with a coarse mesh. A mixture of cement and sand is squirted all over the cylinder with a force of two and one-half kilograms per square centimeter and several cylinders are joined end to end with the same cement. The piles are sixty feet long and from eighteen to thirty inches in diameter and are filled with a square steel head to receive the shock of the piledriver. Each pile weighs about six tons. The advantages of these paper piles as recognized by engineers are increased strength over the solid pile and the fact that they are not attacked by any known insect or marine worm.

Report Movement of North Pole.—Many contributions to the mass of astronomical research, representing investigations of a year by scientists throughout the United States, were presented recently to members of the American Astronomical Society at their yearly meeting in Sproul Observatory at Swarthmore College. Papers read were concerned primarily with methods of eliminating, or at least discovering, errors that constantly hinder advancement of the science. The discussions dealt with such matters as the daily variation in clock correction and the differential refraction on astronomical photographs.

Great interest was shown by the members of the society in the paper read by Walter D. Lambert, mathematician of the United States Coast and Geodetic Survey. His discussion related to earth movements revealed by observations in California which unmistakably indicate a change in latitude. The earth, he believes, is shifting to the north, according to computations in terms of time and space. Study of the movement of the poles showed in addition, Mr. Lambert declared, that the earth does not always revolve perpendicularly on its axis, but that the north pole describes an ellipse, moving as much as sixty feet from its normal course.

A Subway Transit System, controlled entirely from central terminal stations by switch, but not carrying any human operators, is the project of engineers of the Port of New York Authority office. The purpose of the system is to alleviate the distribution of freight throughout New York City and its suburbs. Under the proposed plan, special freight cars carrying wheeled containers and standard freight cars containing perishable foodstuffs would be dispatched from the railroad yards in New Jersey through tunnels under the Hudson River and then by a deep underground railroad to terminals located at various points in New York City. The city tunnel would be under the present passenger subways in order to avoid interference. By closing a switch at a station in New Jersey, it is proposed to send a train of cars direct to any terminal desired, and send the same cars, either empty or loaded with outgoing freight, back in the same way.

The Invisible May Be Photographed by means of what are known as telephoto lenses. The exact nature of the lenses is not made clear by the article which we have at hand, but it appears that by means of them, it is possible to record on photographic plates, the details of objects which are beyond the power of vision of the human eye. As an example, a case is referred to in which a picture was taken of a building first with an ordinary lens and then with a telephoto lens. An enlargement of the latter photograph was made and a pipe which was lying upon a table near one of the windows was clearly discernible while in the former photograph it was, of course, difficult to make out a clear outline of the windows themselves.

Electrification of Italian Railways.—The important problem of electrification in Italy has been tackled with an open mind, giving very satisfactory results in the saving of coal on the lines of heavy traffic, such as the Modane-Bussoleno-Torino, the most important communication between France and Italy and the Ronco-Genoa through the Giovi Pass, which is the principal access to the port of Genoa. The program in course of execution will bring the total extent of electrified lines to 6,000 kilometers in a few years. The program and order of execution gives priority to lines of heavy traffic and when the 6,000 kilometers are finished will represent, according to present calculations, a saving of 2,500,000 tons of coal. The length of 6,000 kilometers represents practically half the total length of the Italian State Railways, but being constituted of lines of heavy traffic, in some cases traffic four times greater than the average on all Italian State Railways, represents a much greater proportion in the saving of coal. Together with the state railways, private companies are electrifying their own railways and together with the general development of hydro-electric constructions in Italy have greatly increased the electric power resources. These are to reach, in 1923, 5,000,000 kilowatts with a possibility of double that in 1925, with the consequent reduction of coal for industrial and general purposes. Electrification in Italy has had real influence in the general economy of the country, giving increased inland development and reduction of burden of foreign coal.

PATENTS

Micrometer Taper-Gage. No. 1,398,296. Charles J. Soguen and James J. Provost.

An article long desired by machinists has been an adjustable micrometer taper-gage. This invention bids fair to fill the need. It consists of a supporting frame with one rest locked in position. The other rest may be set as desired. The amount of taper is obtained from two plugs set at a fixed distance apart into the adjustable rest. One of these plugs only is solidly set, the other being adjustable; a micrometer screw being calibrated to read amount of taper directly.

Method of Concentration of Ores. No. 1,398,394. Hallet Rice Robbins '05. The method is to be used in the flotation process and consists of maintaining a uniformly ascending column of minute gaseous bubbles throughout the entire cross-sectional area of a body of freely flowing ore pulp. At the same time, the pulp is uniformly descending in the tank, and means are provided for elevating the pulp and discharging it uniformly over the surface, thus causing a steady circulation of the pulp. The floated mineral is separated from the remainder of the pulp.

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THE BOIT PRIZE FUND

In the will of the late Robert A. Boit a sum of $5,000 was set aside for the Boit Prize Fund, the income of which was to be awarded in prizes or scholarships to men in certain third year optional courses. The purpose of the awards was "to stimulate the student's interest in the best use of the English language." In the second week of December the prizes for the first contest were awarded. Final judgment was passed on the essays by a committee of three prominent engineers and business men who chose the two essays which showed the best presentation, broadest knowledge, most logical arrangement, and, above all, the best expression and literary style.

The winner of the first prize presented a subject which he knew thoroughly from actual experience, and which dealt with management of men under specific conditions. Many of the other articles were framed from personal experiences with labor and industrial problems.

The motive behind the establishment of this fund is highly commendable, for it endeavors to strengthen Technology men in a fatally weak point. Strong and vigorous English style has never been a forte at the Institute. In fact, American engineers, as a class, are proverbial in their disability to express themselves well, either verbally or in writing. These prizes are meant to force the student to realize the importance of writing clearly and well on industrial and technical subjects. A famous engineer once said that his success was due rather to his ability to express himself than to great knowledge of his profession. Knowledge and ideas are important, but they are useless unless the possessor can express them fully and well.

We should not consider these prizes as something which concerns only a relatively few students, but should realize their true significance. The Boit Fund was established by a business man who realized the great importance of clear expression in business and industry. If we take the hint which Mr. Boit has given, we should seize every possible chance to rectify our weakness. So powerful a weapon as a command of clear and forceful English is surely worth some time and effort.

Let us attempt to remove all ground for the assertion that the American engineer cannot use his mother tongue with correctness and force!

ACTIVITIES AND SCHOLARSHIP

In 1915, Professor Humphreys in an article in the "Technology Review" analyzed the scholastic standing of the students at the Institute grouped under various classifications. He found then that men on the publications,—only The Tech and Technique were in existence,—and in athletics stood well above the average for the whole student body, while the musical clubs, along with the devotees of chess and wireless telegraphy, ranked below.

Just now he has again compiled a list, which is of even more than ordinary interest, in comparison with his conclusions of seven years ago. His figures show that as compared with the general average, represented by the number 183, the rank of men engaged in activities is 190. Here is his complete list:

Activity	Number	Standing
Bench-Mark	8	213
Tech Engineering News	42	210
"T" Team Men	190	195
The Tech	41	192
Managerial Positions	27	192
Voo Doo	21	189
Pofessional Societies and T. C. A. (Officers)	57	188
Ex-Officio Institute Committee	17	187
Technique	26	185
Class Officers, Institute Committee and Dormitory Committee	58	182
Tech Show	64	177
Musical Clubs	43	174
Total	594	190
Whole Student Body		183
Men in Fraternities		177

This subject of the relation of extra-curriculum activities to grades is one of perennial discussion. Alumni, Professors, and College Presidents marshal their facts and figures, set forth their views and arrive at startlingly varying conclusions. No wonder the average man is mystified and alarmed watching such a battle of the giants. We dare not presume in the face of such conflict of weighty authority to assert that these figures prove that the man who makes the Bench-Mark or the Musical Clubs will be an Engineer while the Brown-bagger,—pardon the word; it refers to mental, not physical, attributes,—will always remain an Engineman. They are however significant, tending to show that the man whose interest is entirely absorbed in rotating vectors and dissociating ions does not stand as high, even in his studies, as the man of broader interests. Remember, too, that these standings are weighted, making due allowance for hard and easy courses, and cannot be discredited on the ground that men in activities in general carry less work. So here we are with official figures to back us up able to point a moral even to the H. chasers.

CONCERNING EXAMINATIONS

During the past year or two, there has been a decided reaction in educational circles against the results produced by the established system of formal examinations, and, if we are to judge from the growing amount of comment on the subject in newspapers and periodicals, we must surely form the conclusion that a quest for a better system has at last gotten under way. The need for improvement is great; that fact is patent to all of us who are at present suffering from the evils of the ancient system.

The formal examination is an examination, not of ability or intellect, but of specific information along very restricted lines. Like Thomas A. Edison's now famous tests, the average college examination seeks only to discover whether the individual student is, or is not, a human encyclopedia. If the particular pigeonhole in his brain devoted to the subject in question is sufficiently well-lined with facts concerning that subject, and if the

student can produce a sufficient number of those facts at the time set for the final examination, then he passes the course, and all is well. On the other hand, if a sufficient number of facts concerning the subject is not forthcoming at the appointed hour, then the course is flunked, and all is—something else.

However, let us assume for the moment that a student has completed an examination paper which in his judgment contains all the information asked for. He passes in his paper and goes on his way, feeling secure in the belief that honest effort is bound to receive its just reward. But what a delusion! His feeling of security would quickly evaporate, could he but realize the extent to which his grade on the examination will depend upon the instructor into whose hands the paper may happen to fall. For the amount of variation in grades assigned to a paper, when graded separately by several different instructors, is truly amazing. In one school, for example, a given examination is graded by half a dozen different instructors; the result is a half dozen different grades which may vary from total failure to high honor. A final examination paper in American History was graded by seventy teachers; one teacher assigned to it a grade of 43, another 90; a dozen rated it above 80 and another dozen below 55. A similar test was made at the same time on a paper in Plane Geometry; it was marked as low as 28 by one teacher while another gave it 92; a dozen marked it 53 or below, while an equal number considered it to be worth 83 or more. What further proof is needed to show that something is radically wrong with the present system? That system is not even theoretically sound, since it entirely neglects the "human equation," from the standpoint of the student and of the instructor as well.

To date, we are not aware that any educational institution has proposed complete abolition of the formal examination, but an interesting attempt to minimize the importance of such examinations has recently been made by one of New England's leading secondary schools. The scheme is a novel one, since it consists of the use of intelligence tests to supplement the results of examination and other term grades. Three varieties of intelligence test were given, the results were averaged for each student, and a plot was made, using the average grades as abscissas and the number of students achieving each grade as the corresponding ordinates, thus obtaining a plot of the "broken-line" variety, whose height indicated the percentage of the school's enrollment falling under each grade classification.

Coincident with the development of this plot, each of the instructors was asked to supply the office with an estimate of the ability of each student in his sections, such an estimate being based on the student's regular daily work. This gave roughly seven estimates for each pupil, which were averaged and plotted in exactly the same manner as the averages of the intelligence test scores. When compared, the two plots were found to agree to a surprising extent, the only difference being that the teachers grouped more pupils in the "C," or middle zone, and gave fewer high honors and low failures than the intelligence tests awarded.

To obtain a final index of each student's ability, the average of the teachers' estimates and the intelligence test scores was taken. This average was called the "index of brightness," since it indicates the quality of work which may be expected from the student when he is doing his best. His "coefficient of accomplishments," on the other hand, may be found at any time during the term by dividing the grades he actually receives in his subjects by his index of brightness. This coefficient of accomplishment is thus a measure of the student's efficiency; if he is working conscientiously, he should be readily able to achieve 100% efficiency, in which case his coefficient of accomplishment would be unity.

MUST THE UNIONS GO?

The man who invented trade unions had a good idea, from the standpoint of the laboring classes. Trade unions have resisted the imposition of unfair rates of pay upon their members; they have kept the workers posted as to existing wages and market conditions; they often act as mutual insurance associations, providing benefits in case of sickness or temporary unemployment; they frequently secure the passage of needed labor legislation before the community at large has become aware that a change was necessary. One English writer goes so far as to say that each trade union is in itself a miniature democracy, teaching its members valuable lessons in self-government, and increasing their understanding of economic and political problems.

Thus there is no doubt that trade unionism is a fine thing for the laboring man. But what about the rest of the community? Are the ninety-eight million people in this country who do not belong to trade unions any better off for the activities of such unions? The answer is obvious: they are not.

Perhaps only inconvenience may be caused when the operatives in a large automobile or motor truck plant strike for higher pay or shorter hours, but when the industry involved happens to be one whose continued operation is essential to the welfare of large classes of people, then the result may be, not only inconvenience, but downright hardship and privation. The recently averted rail strike is a most noteworthy example. Had this strike been allowed to materialize, there would have resulted a wholesale tying-up of commerce and the transportation of needed foodstuffs, from one end of the country to the other. Evidently, the instigators of such an outrage could have had no slogan other than "The public be damned," in thus attempting to further their own interests at the expense of every other class in the community.

Not only have the trade unions grown callous in their disregard for public welfare, and often entirely unreasonable in their demands for a still fatter pay envelope or an even more luxurious "working" day, but, having obtained what they are after, they are quite apt to treat their collective bargains with employers like the now proverbial "scrap of paper," casting honor and discretion to the winds. A case in point is that of the San Francisco building-trades strike last summer. The Building Trades Council refused to abide by the decision of an impartial arbitration board, which the Council itself had helped to appoint, and struck, in flat repudiation of its agreement to respect the board's findings. Such a repudiation aroused a storm of public protest, with the result that the American plan, or "open-shop" principle of employment was successfully established within six weeks from the date of the strike.

In fact, all over the country, industrial cities are becoming weary of the ills of trade unionism, and, knowing no other remedy, are turning to the open shop as a solution of the problem.

But the open shop is not in itself a complete remedy, for it reduces the workers to the same position of inferiority they occupied previous to the coming of the trade union. The bargaining power of the isolated laboring man is indeed small; if the unions are to go, then the individual worker must not be left entirely unprotected. It is quite likely that, in those cities which turn open shop, the unions will not be entirely abolished, they will continue to exist, their activities greatly curtailed, it is true, but retaining sufficient power to act as a check upon the tendency of employers to regard labor as a commodity to be purchased at the lowest possible price. Then, indeed, will the unions be doing the laboring man a real service; instead of filling the heads of their own members with exalted notions concerning the value of their labors, they will be working in the interests of all, union and non-union men alike, and perhaps will come nearer than at any other time in their history to fulfilling the purposes for which they were created.

BRIDGING THE MARNE

By CAPT. W. F. HEAVEY, '22

Graduate, United States Military Academy

The Germans had made their expected attack on the Marne front on July 14-15, 1918, and had gained a few kilometers on the French part of the front, but had been stopped far short of their first day's objective on the front of the Third U. S. Division. Instead of gaining the 18 or 19 kilometers from the Marne to the town of Montmirail, which a captured German plan of attack had indicated as their objective for the first day's attack, the Germans had gained only a few hundred yards on the U. S. front and soon had to give this up. Their retreat from this section led all the way to Sedan, and only ended with the Armistice.

The Sixth Engineers was the Engineer regiment of the Third U. S. Division which held the front from Chateau Thierry to the Surmelin Creek, a distance of about five miles. During the attack by the Germans, the losses of this regiment were very heavy, in fact, almost as heavy as the infantry regiments. Some of the Engineer units fought as infantry during the attack. One of the companies, C Company, lost 92 men as casualties out of its strength of 240 before the attack began.

After the counter-attacks at Soissons had been made and the Crown Prince had begun to withdraw from the Marne Salient, orders came for the Third Division to push the Germans back from the Chateau Thierry region. At that time the Germans were back in their original position on the north bank of the Marne and the Americans on the south bank. On the 21st, immediately after the receipt of the order to advance, the Engineers were called on to throw bridges across the Marne.

The first job was to get enough infantry across the river to drive the Germans back from the commanding hills on the north bank. It was generally known that the Germans had begun their retreat, but the artillery and infantry fire left no doubt as to their intention to oppose the crossing of the Marne.

The Marne, in the vicinity of Chateau Thierry, is a rapid stream, about 140 feet wide, with a depth varying from six feet near the banks to ten or twelve feet in mid-stream. The bottom is fairly firm except in mid-stream where it is quite soft. The main road from Montmirail to Fismes crossed the Marne at Mezy. During their retreat in May, 1918, the French had destroyed the fine concrete arch bridge at that crossing in order to delay the Germans. All other bridges along that section of the Marne had been destroyed, either by the French or by the Germans.

Two Engineer companies were assigned to the task of putting in the foot-bridges for the infantry. Patrols were able to investigate the Marne about dusk on the 21st, and two locations were selected for the foot-bridges, one at Mezy and the other at Fossoy, points about a mile apart. The patrols were careful not to disclose the selected locations, but in fact were able to attract fire at a few points quite different from the points actually selected, in order to mislead the Germans.

In July, 1918, the standardized portable foot-bridges had not reached the front so it was necessary to throw across improvised bridges. Empty gasoline bidons and any other buoyant material that could be found in the vicinity was hastily assembled, and, with plain duckboards as the stringer and floor system, the improvised bridges were soon made ready. An hour before dawn on the 22nd, the bridges were in position, and, at dawn, the infantry went across. By ten that morning they had driven the Germans back from the hills on the north bank.

PONTOON BRIDGE ACROSS THE MARNE
Built by the Sixth Engineers with captured German pontoons.

The infantry could not push far without artillery, food, ammunition, etc., so the next task for the Engineers was to get artillery and transportation across the river. Due to lack of shipping, the Americans had not brought their pontoons to France, depending on the French for them. However all the French pontoons in the vicinity were being thrown across on their front. In this emergency, the Engineers found that some of the pontoon boats, which the Germans had brought down to the river for their attack, were more or less serviceable. They were quickly repaired, rags stuffed in the holes, and the boats and material were collected. During a night of pouring rain and continual shelling of the river banks and the roads leading to it by the Germans, a pontoon bridge was thrown across. Early on the morning of the 23rd, the first vehicle passed over the bridge with rations for the hungry infantry.

However, the pontoon bridge, improvised from captured material and with some of the boats so leaky that they had to be bailed almost continually, was not strong enough to take artillery and heavy trucks. On account of this, orders were received on the morning of the 23rd to erect a bridge capable of taking up to and including six inch artillery. The six inch gun used by the Americans weighed about 26,000 lbs. No material seemed available for a bridge of this strength, but scouting or salvaging parties were sent out in every direction and a varied supply of materials was collected at Mezy, where the heavier bridge was put in. In the collection were telegraph poles, railroad rails, floor joists, and beams from some of the half-demolished houses in Mezy, and a small supply of lumber found in a partly destroyed lumber yard.

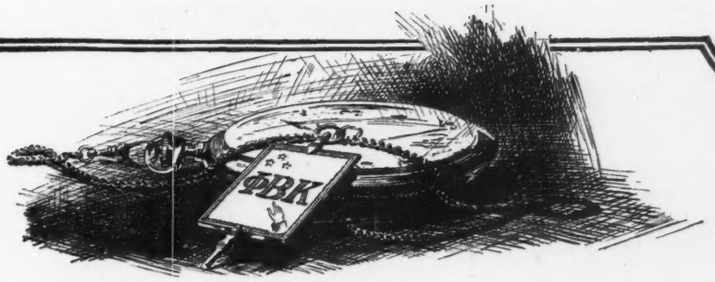
By noon on the 23rd, work was started on a trestle bridge. As an engineering structure, the bridge was quite crude. However, speed was the essential point, and it made no difference whether the bays were of uniform length or not. As a matter of fact, one bay had rails as stringers while another had telegraph poles and so on. In mid-stream, it was necessary to put in two cribs instead of trestles.

Shifts were arranged so that it would be a continuous job, night and day, and work was started from both banks and pushed vigorously. The night shifts were naturally hampered by the fact that no lights of any kind could be used. On the evening of the 23rd, the Germans were not more than about a mile from the river, and they had direct observation on the location where the bridge was started. By nine o'clock the next morning, "Fritz" had discovered what our intentions were and from then on, the bridge received particular attention, at intermittent times, from their artillery. Several shell fragments hit the bridge but did no material damage.

The first two nights the German bombing planes hampered the night shifts a great deal. With the river glistening in the moon-light to guide them, they had no difficulty in finding the bridge, but they did no damage to it although they caused some casualties among the Engineers.

At 8 A. M. on the 27th, the bridge and its approaches were ready and the bridge was opened. For eighty hours, there was an uninterrupted stream of traffic across the bridge—artillery pieces, ammunition and ration trucks, ambulances, etc.

The Sixth Engineers received the Croix de Guerre with palm for their work.



Does it hurt much to own one?

THERE is a campus saying that if a man has won a Phi Beta Kappa key or other honorary fraternity emblem, he had better keep it out of sight when he goes looking for a job.

Still there are men who ranked high at college and who haven't turned out altogether failures in life. Strange though it may seem, more and more such men are winning positions pretty high up in the commercial and industrial world.

Call it chance. Say they succeeded in spite of their scholarship. But, seriously, is it too much to trace a logical connection between a man's proficiency in getting ready for his vocation and his success in that vocation?

Surely it is common sense that the better grip you get on your work now, the more easily you can handle the big jobs later on.

This question of scholarship is far bigger than whether you like a certain emblem and the men who wear it. The value of the emblem is what it stands for—knowledge and the ability to think straight.

Develop this ability where and how you will, but develop it—because in the world of affairs they reward it liberally.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

Western Electric Company

Maybe it's against all campus tradition, but some men who stood high at college and who entered this Company years ago have since become its executives.

STARS AND ATOMS

(*Continued from Page 204*)

brightness with the brightness they appear to have is a key to the distances of stars.

When we speak of variable stars we ordinarily mean only those that vary in light, although stars are known to vary in position, velocity, color, and other properties. An important and frequent class of variable star is the eclipsing binary—a double star whose components are moving in a relatively small orbit so inclined to the observer on the earth that the light (which is seen as a point source) is periodically and temporarily diminished through eclipses. Algol, the second brightest star in the northern constellation Perseus, is the best known member of the class. The systematic study of the brightness of such a double star permits the derivation of a light-curve, that is, a plot of magnitude against time, showing the variation of the light throughout the course of a complete revolution.

The mathematical analysis of the light-curve of an eclipsing star gives information about the orbital elements, the surface brightness, the stellar dimensions, and other physical properties, including the candle power, which is the quantity that is important for studies of stellar distance. Of the ninety eclipsing binaries whose distances I have derived in collaboration with Professor Russell, two-thirds are more distant than a thousand light-years, quite beyond the sphere of accurate measurement by trigonometric methods, and a number are more than five thousand light-years away.

As a class these eclipsing binaries are intrinsically very bright relative to the sun. Similarly, the Cepheid variables are giants in absolute brightness. They are always, in fact, more luminous than a hundred suns, and those which are equivalent to a thousand suns are typical members of the class. Much attention has been given them in recent years. They are known to vary continuously and synchronously in color, apparent velocity, and spectrum, as well as in stellar magnitude. They seem to be single stars, rather than binaries, and their variations are interpretable as periodic pulsations in gigantic volumes of luminous gas. The periods of pulsation are in some cases but a few hours, in others, several days or weeks; but for any given star the period is usually constant within a small fraction of a second. A quick rise to maximum light, followed by a slower decline to minimum, characterizes the typical Cepheid light-curve.

No class of stars is of greater significance in modern stellar astronomy than the Cepheid variables, because of their wide distribution throughout the known sidereal universe, their peculiar bearing on questions of the dynamics of stellar evolution, and their very high importance in problems of sidereal distances.

The determination of absolute magnitude and distance is a much more direct and accurate process for Cepheid variables than for eclipsing binaries, for the absolute brightness is empirically found to be uniquely determined by the length of the period of variation.

Although the eclipsing binaries and the Cepheid variables are actually very bright, many of them appear exceedingly faint because of distance. They permit us, therefore, to go out much farther into space than we had hitherto gone. But it is not in exploring the immediate vicinity of the sun that these variables contribute so much to knowledge of the structure of the universe. It is rather through their frequent occurrence in other remote stellar organizations, such as globular clusters, that they aid greatly in fathoming the sidereal system; for in giving us their own distances, the variables in clusters are at the same time revealing the distances of the vast assemblages of which they are members.

It is by means of these new methods of measuring distance that we have been able to estimate that the diametor of the known stellar system is as least 300,000 light years, rather than the twenty or thirty thousand light years until recently assigned it. The Cepheid variables have helped to prove that the stellar system is not heliocentric, but that the Sun is probably some 60,000 light years away from the center.

Another type of photometric procedure is involved when the absolute magnitudes of stars are estimated from the

(*Continued on Page 224*)

AUBURN THRUSTS

Answer Problems Like This

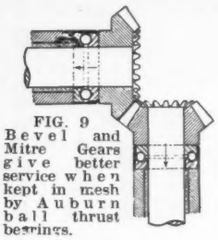


FIG. 9 Bevel and Mitre Gears give better service when kept in mesh by Auburn ball thrust bearings.

Send for data sheets showing how several problems have been answered with Auburn Thrusts.

Steel, Brass and Bronze Balls

Catalog on request

AUBURN BALL BEARING CO.
44 Elizabeth Street
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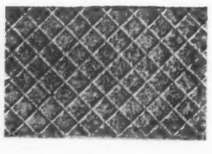
Safety Treads



Approximately 1500 people are killed in the United States each year by falls. The economic waste from this source is over $140,000,000.

About one-third of the "Falls" are preventable by the use of safety treads.

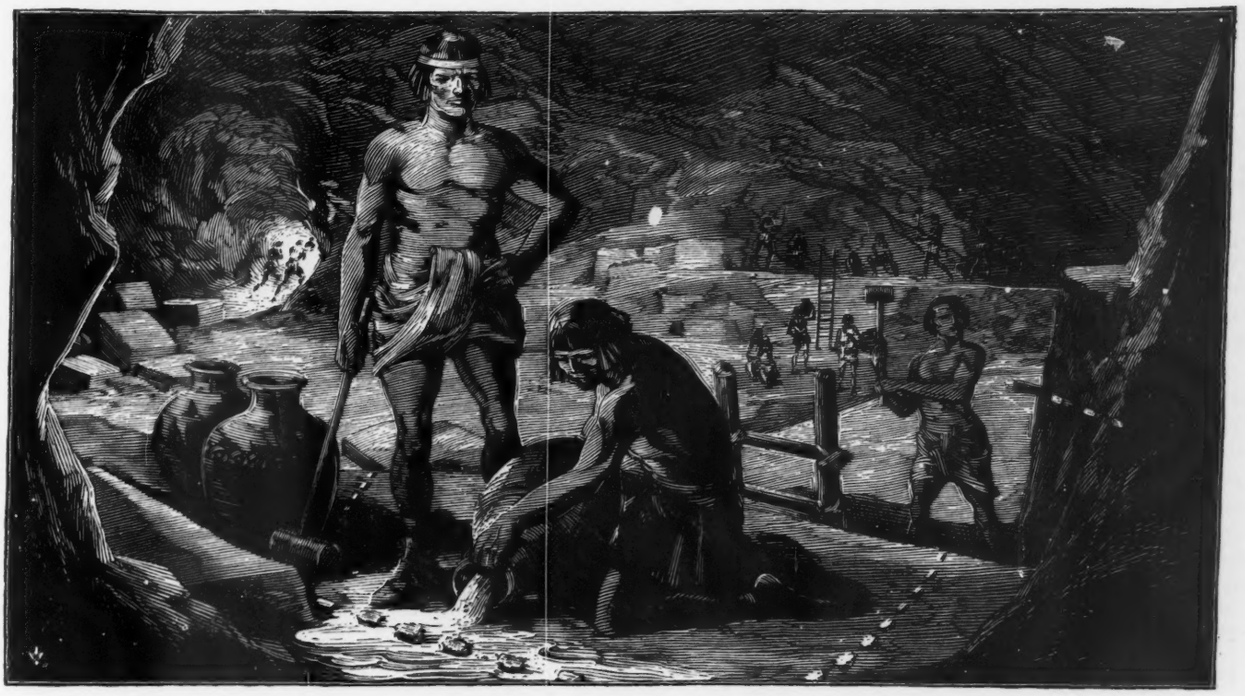
The selection of the type of Safety Tread is important.

Treads with a series of grooves parallel to the nosing edge, that are porous, that corrode readily, that have names falsely giving the impression of safety features not possessed, should be avoided.

Be sure the Safety Tread YOU adopt is SAFE; that it is not a germ incubator, absorbent, easily stained; that it has no eye-confusing and heel-catching grooves; and that it does not deteriorate on account of corrosion.

Consider FERALUN and BRONZALUN treads.

American Abrasive Metals Co.
50 CHURCH STREET, NEW YORK CITY
M. C. TOMPKINS '06, 136 FEDERAL ST., BOSTON
NEW ENGLAND REPRESENTATIVE



Mining for King Solomon's Temple

Eighty thousand workmen with the quarrying tools of antiquity toiled in the subterranean quarries from which King Solomon obtained the pure white stone for his Temple—begun in 983 B. C.

Channels, to mark the dimensions of the blocks, were grooved in the rock wall with picks, crudely fashioned of bronze. The Egyptian method of breaking out the rock was used: into a niche cut in the stone, a dry wooden wedge was pounded and water poured in upon it. The swelling of the wood forced out the block.

The rough and smooth ashlar of which the temple was built was worked down to the desired size in these caverns. Seven years were consumed in building the temple.

At a modern copper mine, 47,000 tons of ore have been produced in one day with the aid of Hercules Explosives. And more than 25 million pounds of Hercules dynamite have been used at this mine without a single accident due to the explosives.

King Solomon's craftsmen labored for many days to accomplish as much as one pound of Hercules dynamite will now do for you in a moment.

Write to our Advertising Department, 942 King Street, Wilmington, Delaware, for a book on Hercules Products.

HERCULES

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Pottsville, Pa.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Wilkesbarre, Pa.
Wilmington, Del.

COURSE X-A

(*Continued from Page 203*)

Baseball, tennis, and bowling were big sports. Nearly every week, two or more of the group would take camping trips over the week-end. With a camp pack, provisions, pup tents, and other equipment, we went on hikes and canoe trips out into the wooded country surrounding Bangor, pitching camp when darkness came on. Also nearly everyone spent a day or a week-end at Bar Harbor.

At the Boston Station we studied the heavy chemical industry at the Merrimac Chemical Company, including the manufacture of chamber and contact sulphuric acid, nitric, hydrochloric, and acetic acids, alum, and Glauber's salts. Plant layout, materials of construction and their corrosion, and disposal of waste products were carefully watched. At the Revere Sugar Refinery we studied sugar production; and refining, and production methods were investigated at the United States Rubber Company. At all plants, there was afforded ample opportunity to study plant layout, organization, routing of materials, and storing of raw and finished products.

ANALYZING SULPHITE LIQUOR
Determining the relative efficiency of "bubble" and coke filled absorption towers.

Among the most valuable faculties brought into play and developed was that of learning how to meet and deal with workmen, so that there was no feeling of uneasiness on either side; so that the workmen were pleased to have you work beside them, and give you information about the plant as they knew it. Quite often some of the most valuable recommendations for improvement in the plants visited had their germination in the heart to heart chats with workmen on the job, some of them hardly able to speak English.

The American Chimney Corporation of N. Y.

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New England States Mgr.
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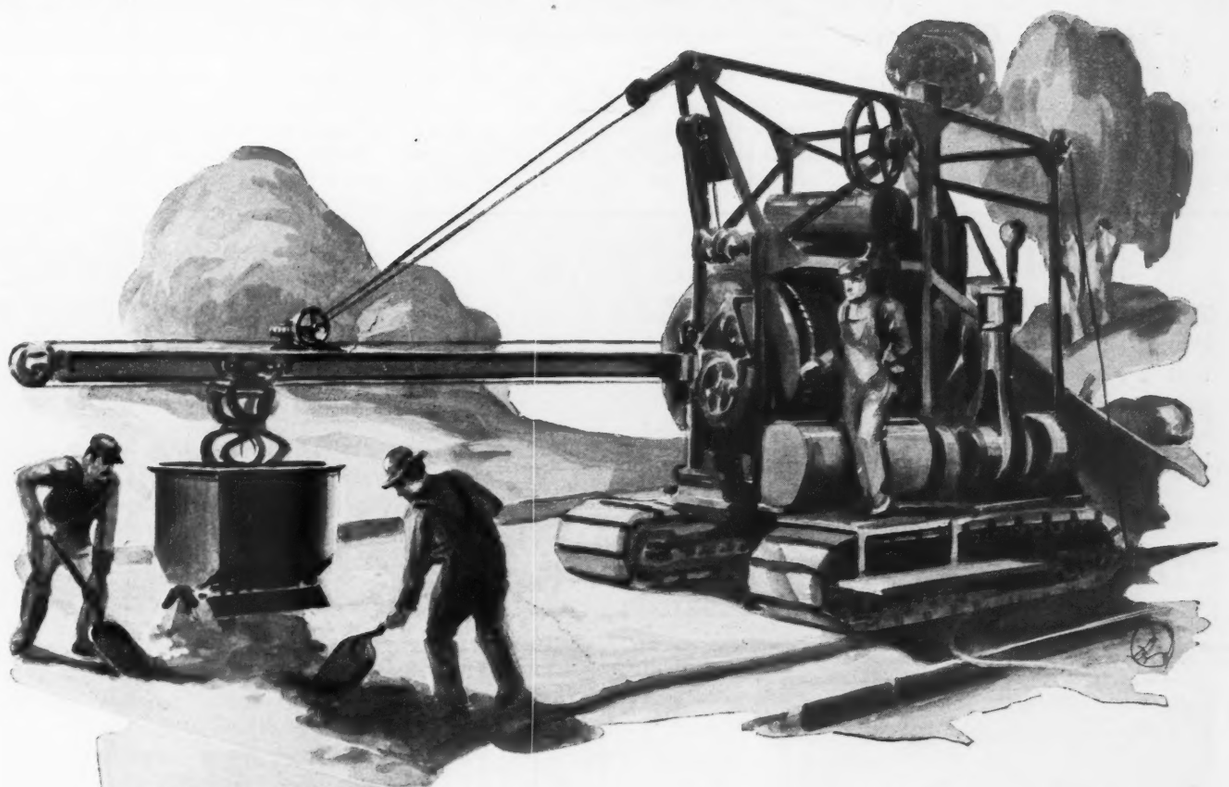
ACCURACY

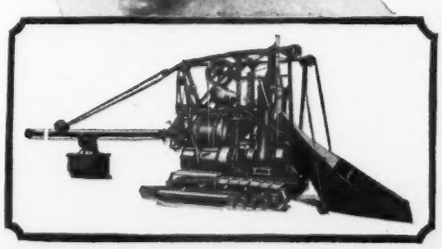
If your printed brochures, treatises and bulletins are to be of any value they must be fully as accurate in text and illustration as the machines, materials or processes which they describe.

For more than twenty years this Company has advanced through its ability to supply *accuracy* in all forms of printed matter at the most economical cost.

PERRY & ELLIOTT CO.
146 Summer Street, Boston
Specialists in School and Commercial Printing
Plants at Lynn and Salem

MERRIMAC CHEMICAL COMPANY
BOSTON
CHEMICAL MANUFACTURERS





Brick on Concrete Foundation

A brick pavement with concrete base forms a most satisfactory and enduring type of road. It has its firm adherents in various sections of the country.

As in all other fields of concrete construction work, the Koehring Company offers equipment especially adapted for mixing and placing the concrete base on this type of two course roadway.

The Koehring Paver comes equipped with either road wheels or multi-plane traction, the latter facilitating operation in muddy or soft ground. For moving the heavy machines over city streets, pavers have even been equipped with solid rubber tires.

The twenty foot long boom, with its automatic, self-spreading type bucket places the mixed concrete quickly and with a minimum of hand labor. And for working in restricted quarters, the compensating distributing spout operates to good advantage.

KOEHRING COMPANY

Manufacturers of Concrete Mixers and Locomotive Cranes

MILWAUKEE, WISCONSIN

KOEHRING

STARS AND ATOMS

(*Continued from Page 220*)

spectral characteristics. This remarkable method, developed and extensively used at Mount Wilson by Adams, Kohlschutter, and others, depends upon the condition in the stellar atmospheres of the chemical elements. Briefly stated, the candle power of a star, of given surface brightness (spectral type), depends upon its surface area, which in turn depends also upon the mean density. The concentration of "electron gas" in a stellar atmosphere depends also upon the mean density, and this concentration determines what proportion of the atoms, that have lost electrons because of the high temperature, will remain ionized.

If the spectral lines due to the radiation of ionized atoms of some particular element are strong, we infer that many of the atoms of that element, after losing an outer electron, remain in the ionized condition because of the low concentration of free electrons available for restoration to a normal state. The low concentration indicates that the density of the stellar atmosphere is low, that the surface is large, and the candle power high. On the contrary, a weak spectral line due to an ionized gas indicates quick recovery of the atoms ionized by the high temperature; it indicates, therefore, a denser stellar atmosphere, a small volume and surface area, and low candle power. In other words, the so-called enhanced or ionized spectral lines are strong in the low density giant stars and weak in the denser dwarfs, and their intensities can be used quantitatively to determine the absolute brightness.

Some elements like strontium, manganese, calcium, potassium, and rubidium are particularly susceptible to the ionizing effects of temperature and concentration. The first three are of special value in measuring the absolute brightness of stars.

A spectrophotometric method of measuring stellar distances is first calibrated by means of stars at known distance and spectral characteristics, and is then applied to all objects of suitable types within the range of modern stellar spectroscopes.

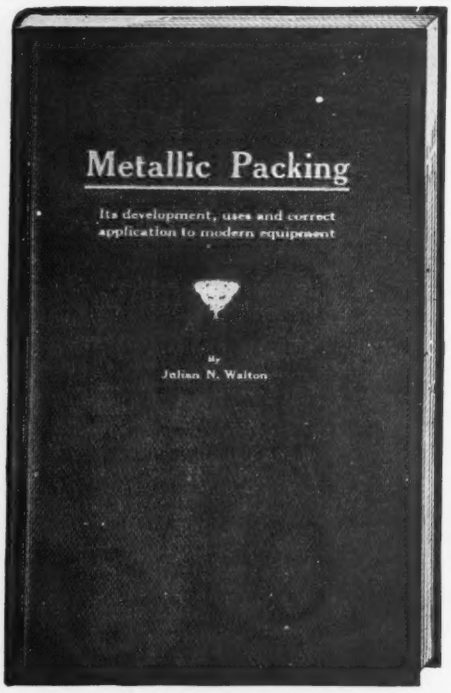
The procedure involves knowledge of the behavior of gases under high excitation. It is but one of the developments of astrophysics which show that to know stars thoroughly we must first understand something of the atom; and that to comprehend completely the smallest known material things, with diameters less than a billionth of an inch, we can with advantage study the giant star, a hundred million miles in diameter.

INDUSTRIAL PRINTING

The Murray Printing Company is located at Kendall Square, Cambridge, in its own modern and commodious building, with a plant that is efficient in every detail. The firm has been established one-quarter of a century and handles the printing of catalogues, periodicals and technical books. The firm's list of customers includes many large manufacturers and publishing houses of New England.

Always ready to intelligently co-operate with you on your printing requirements.

THE MURRAY PRINTING COMPANY
KENDALL SQUARE, CAMBRIDGE



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Some day you'll be a
Chief Engineer
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At that time you will have to know something about

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Get this information now before the second edition of "Metallic Packing" is exhausted.

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94 MASSACHUSETTS AVENUE
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Distributors of
HOLT CATERPILLAR TRACTORS CLETRAC TANK TYPE TRACTORS
Manufacturers of Snow Plows, Sleds, Trailers, and Logging Equipment

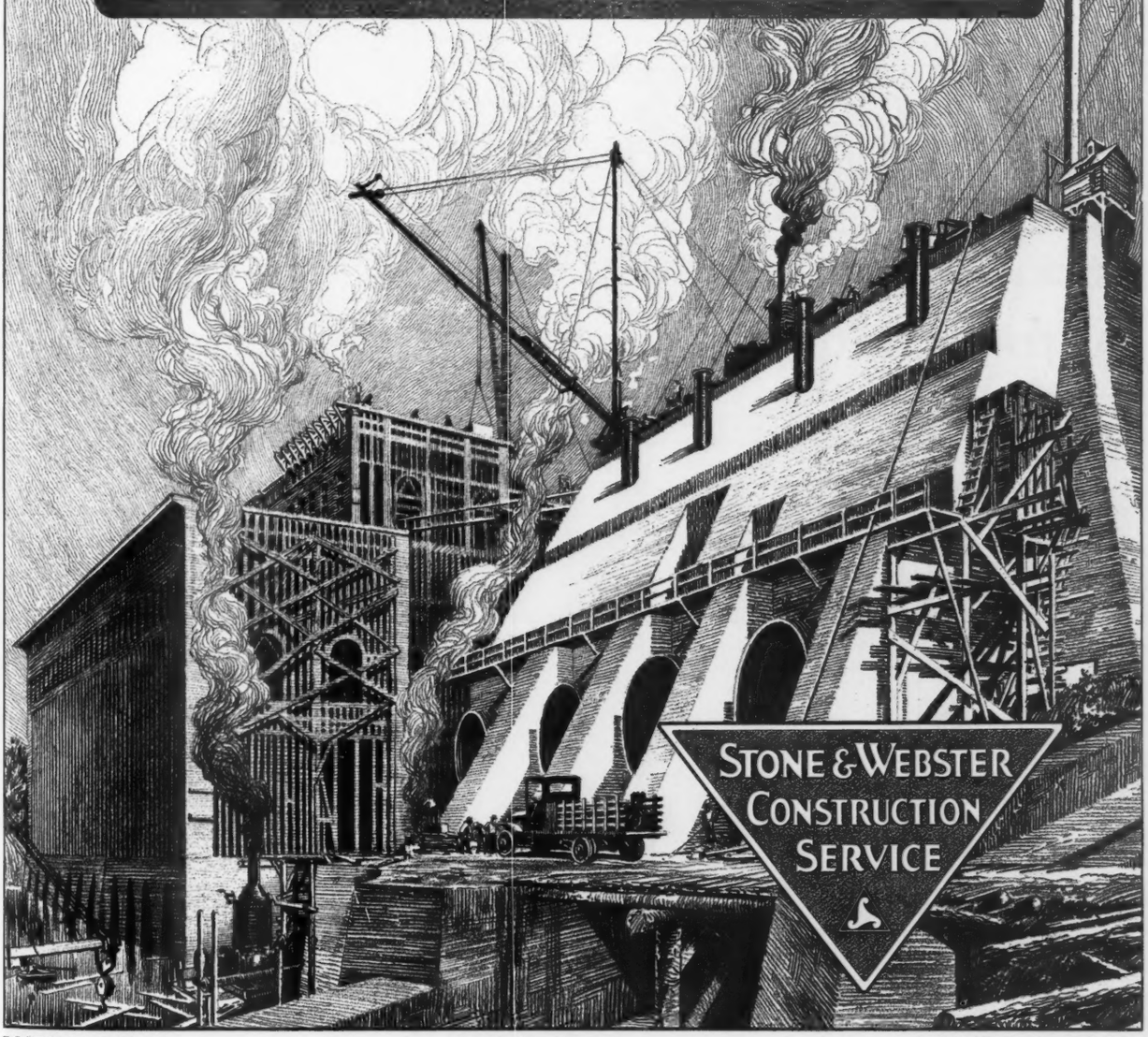
Power Dams of America

HIGH dams for storage, low dams for diversion, dams of concrete, masonry, earth-fill and timber are found in the water power developments designed and built by Stone & Webster.

Water is stored by the millions of acre feet, sometimes by barring broad rivers in the plains states, sometimes by sealing mountain streams at great altitudes. One of these reservoirs of power is *seven thousand feet above the sea*, the highest in America; another is *fifty miles in length*, probably the largest in the world.

Each of these Stone & Webster undertakings is the embodiment of a construction service that works everywhere, and co-operates with the client's organization from the shaping of his plan to the delivery of his completed work.

STONE & WEBSTER
INCORPORATED



BOSTON, 147 Milk Street
SAN FRANCISCO, Holbrook Bldg.

NEW YORK, 120 Broadway
CLEVELAND, Leader-News Bldg.

CHICAGO, 38 S. Dearborn Street
PITTSBURGH, Union Arcade

DRAFT TUBES

(*Continued from Page 205*)

only dispersed across the plate in straight stream-lines but also that the ninety-degree turn was accomplished with practically one hundred per cent efficiency. The action of the jet as it struck the plate was to produce a conoidal portion of water which Mr. White called the "hydraucone action" of the water. It is this action which is the basis for the White hydraucone regainer. It will be noted that at least after the water strikes the plate, the stream-lines are parallel and therefore the static-head may be efficiently regained as before explained.

Mr. Moody observed that when a vessel containing water was allowed to discharge through a hole at the bottom, the water formed a free whirling vortex. As a particle floated nearer to the vortex, the greater was its velocity, reaching a maximum after passing through the hole. The Moody tube reverses the free vortex conditions, considering the vessel turned upside down. The hole may be regarded as the runner discharging water in a direction opposite to that of a free vortex. Instead of a self-made cone of air, as is the case with a free vortex, a concrete cone is placed in a draft-tube whose walls spread outwardly after the manner of the spreading vortex.

Considering all the designs mentioned, tests under similar conditions show that the radial type is far superior to the short straight or elbow tubes. In tests of the White and Moody, there seems to be but little choice as far as efficiency is concerned. It will be noted, however, that the Moody design takes into account the whirling discharge, whereas the formation of a pressure hydraucone would seem impossible under whirling conditions. On the other hand, at best gate, the concrete cone in the Moody design not only increases frictional losses, but also positively prevents the formation of the hydraucone which so efficiently turns the water through the ninety-degree bend.

The tests on the radial tubes as against the older designs prove conclusively that the radial type is a long step forward. It is neither the purpose of this article nor the ability of the writer to say which of the two radial designs is the better, but rather to acquaint the reader with the conditions existing inside the different forms of draft-tubes and call attention to the improvements embodied in the new types. It is evident that there are improvements yet to be made in eliminating eddy losses even with the newest designs.

It is of fundamental importance, in these days of development of hydraulic power, to realize that the draft-tube is, in a great measure, responsible for high efficiency and steady operation of the hydraulic turbine. An efficiency of ninety per cent or over, capable of being attained by a carefully-developed turbine runner, may be seriously lowered by disregarding the importance of correct draft-tube design.

The Smallest Airplane in the world, known as the Ricci triplane, has recently been completed by an Italian aeronautical engineer. The diminutive plane has a wing spread of only twelve feet, and has developed a speed of 110 miles an hour in a test flight over Naples.

ARTHUR C. HARVEY CO.
IRON
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506 CAMBRIDGE STREET BOSTON 34, MASS.
Telephone Brighton 3800

GENERAL WELDING & EQUIPMENT CO.
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ENGINEERS AND CONSTRUCTORS
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NEW YORK
CHICAGO YOUNGSTOWN DALLAS LOS ANGELES MONTREAL

To Advertisers:

PUTTING THE CART BEFORE THE HORSE

We have received many letters like this one.

"In reply to yours of January 24th, believe there will be very little possibility of our contracting for space in your publication this year. While conditions show a slight change for the better, we are not over-optimistic about our advertising expenditures for the coming year."

We have also received letters of renewal stating that very satisfactory results have been obtained from advertising with us. There is a reason for this.

It is not logical to wait for orders to come in before placing advertising. To get results, it is necessary to advertise first. This is putting the horse before the cart where he belongs.

There is a second consideration, that of motivation. In order to make the horse go, you must start him off by a touch of the whip or the reins. To make advertising go, copy must be written so that it will sell the product.

Gentlemen, let's put the horse where he belongs and help do away with the present business gloom instead of waiting and shaking our heads in despair.

Published in the interest of Better Business by

THE TECH ENGINEERING NEWS, Advertising Department.

WILLIAM T. REED CO.

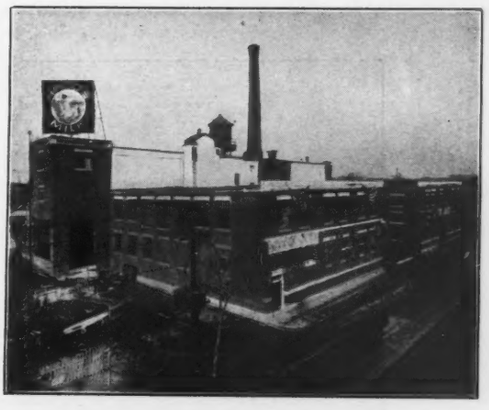
Building Construction

201 DEVONSHIRE STREET, BOSTON 9

INDUSTRIAL CONSTRUCTION — SLOW BURNING OR FIREPROOF

FORMERLY

NEW ENGLAND CONCRETE CONSTRUCTION COMPANY

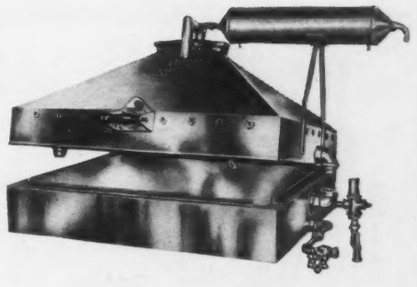


FOR THE TANNER'S LABORATORY

3613 Water Bath, Alsop's, for evaporations, especially in tanners' laboratories. Made of heavy copper throughout, tinned inside, with polished brass fittings. It is mounted on a heavy angle iron stand. The condenser is mounted on the lid and the condensation may be used as distilled water. Size, 25x20 inches, for 60 crystallizing dishes 2¾ inches in diameter.

3613A ————, size, 35x25 inches, for 110 crystallizing dishes 2¾ inches, in diameter.

PRICES ON APPLICATION



L. E. KNOTT APPARATUS COMPANY

MANUFACTURERS OF SCIENTIFIC INSTRUMENTS

79-83 Amherst Street **Cambridge 39, Mass.**

Burton-Furber Coal Co.

Sole Retail Agents

CROZER-POCAHONTAS COAL

Selected Grades of

ANTHRACITE COAL

50 CONGRESS STREET

BOSTON, MASS.

In Winter or Summer

IMPROVED PROCESS

ECONOMY GREASE

never changes its original consistency. It is manufactured from Pennsylvania refined mineral oil and contains absolutely no fillers such as soap stone, asbestos, talc, clay, rosin, etc., of which so many cheaper greases are made up.

Do not just "get by" on your lubrication. Take pride in the quality of the lubricant in your plant. You will find that in the long run you will save yourself a great deal of worry and bother and that your machinery will serve you better and longer.

Economy is used at the M. I. T. Power Plant, as well as by New England's largest machinery manufacturers, textile mills, etc.

We emphasize service, most orders leaving our factory within a few hours after their receipt.

Established 1909

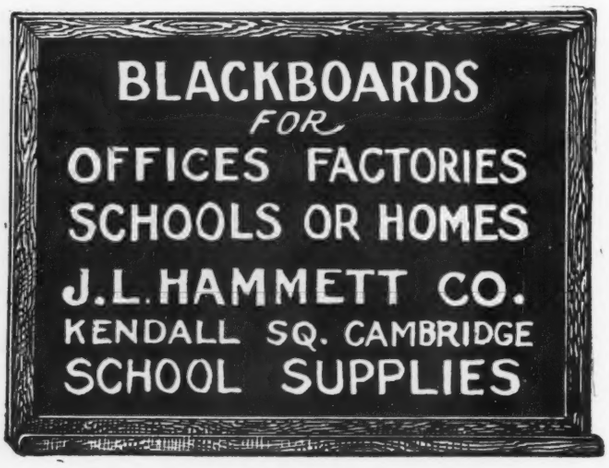
Economy Lubricating Co.

SOLE MANUFACTURERS

Harry H. Atkinson, Prop.

Works and Office

Charlestown 29, Boston, Mass.



PROFESSOR MILLER

(*Continued from Page 209*)

Training Corps Unit for the Ordnance Department of the United States Army, open to undergraduate students of the Institute, has been established. He has also been largely instrumental in the establishment last summer of the Ordnance School of Technology and the Ordnance School of Application for training Ordnance officers of the United States Army in the branches of engineering particularly needed in their profession.

In recognition of his services to the War Department Professor Miller was commissioned a Colonel in the Ordnance Department of the United States Reserves on Jan. 14, 1922, an honor rarely granted to a civilian in times of peace.

Mainly through Professor Miller's efforts, in conjunction with some of the Army officers who are attending the Institute at the present time, an M. I. T. Army Ordnance Post has been established at the Institute. This Post, to which Ordnance officers attending the Institute for various courses and members of the R. O. T. C. are eligible, is a branch of the National Army Ordnance Association and membership in it is esteemed a valuable privilege.

Professor Miller has always been a close friend of his students and has given without reserve his time and strength in work on their behalf. In this direction he was instrumental, a number of years ago, in founding the Student Section of the A. S. M. E., in which he has always taken a personal interest. As a mark of their esteem he has been elected a member of the Phi Sigma Kappa and Theta Tau Fraternities.

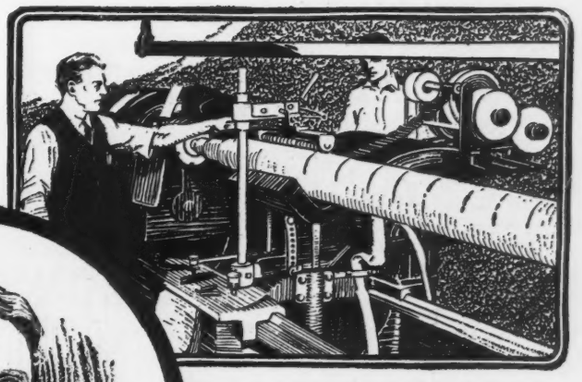
While he is a firm believer in the importance of a thorough training in the fundamental theories on which engineering practice is based and that mastery of these is necessary for the trained engineer, Professor Miller has always made it his aim to keep closely in touch with the current methods of good engineering practice. As a result he is able to bring to the class-room a large fund of knowledge, based on his own personal experiences as well as those of others, and to illustrate the application of the principles he is teaching in a very practical way.

LUFKIN TAPES SCALES WOOD RULES

RELIABLE, PROGRESSIVE LINES THE RECOGNIZED STANDARD

Send for Catalogue **THE LUFKIN RULE CO.** SAGINAW, MICH. New York London, Eng. Windsor, Can.

Winding high voltage insulation, 1894—2,200 Volts



Winding high voltage insulation, 1921—220,000 Volts

Charles E. Skinner

WHAT is insulation?—a necessary evil;—the insulation engineer?—likewise a necessary evil;—such, too often, was the oldtime formula. What wonder, with such a stigma, that the vast majority of budding engineers of bygone years side-stepped that branch of the electrical art which was in such ill-repute.

Fortunately, a few far-visioned young men of unusual caliber saw the great possibilities in this field of endeavor and concentrated many of their best years upon it. Foremost among these few who have developed the insulation problem to a leading position in the art, stands Charles E. Skinner, the head of the Research Department of the Westinghouse Electric & Manufacturing Co.

For over thirty years, Mr. Skinner has been delving into the whys and wherefores of the insulation problem, from extreme theoretical studies to the most practical applications. His work began at a time when there were no theories worth while to consider, and when there were no methods worth while to work with. It was not only necessary to develop the insulation art from the ground up, but all the tools of attack had to be developed, and this latter means far more than mere words can convey.

As an insulation engineer, Mr. Skinner has always faced the necessity of utilizing a great array of materials which are inferior in mechanical characteristics to those of the rest of the structure, such as papers, fibers, cottons, fabrics, mica, varnishes, asphaltums, oils, and various other unmechanical materials. Such materials are practically all affected, or destroyed, by undue heat. Many of them are easily penetrated by moisture, the arch enemy of insulation. Practically none of these materials individually is ideal for the purpose desired, nor are they perfect in combination. Consequently, the history of insulation is a story of struggle, of frequent disappointment, and oftimes mysterious failure.

It is now fully realized that the insulation engineer is a vital and constructive factor in the development of the electrical art. With the great advances in recent years his high position in the art is becoming more and more recognized, as the difficulties of his problems are better realized. It may be said truly, that the high position of the Westinghouse Company is due, to a large extent, to the far reaching accomplishments of its insulation engineers, of whom Mr. Skinner is the leading exponent.

Westinghouse

WESTINGHOUSE ELECTRIC

This advertisement appears in all the prominent college magazines in this country.

SEAMLESS TUBING

(*Continued from Page 207*)

ing," and is really a combination of extrusion and boring. The three essential parts of the machine are a pair of crested drive rolls, a cylindrical guide roll and a piercing mandrel. The crested drive rolls are set to grip the bar and, due to the angle between their axes, they drive it forward with an intense pressure. As the bar travels forward it is met and its end opened by the piercing mandrel, thus tending to produce a tube. The guide roll controls this operation and shapes the metal into a crude shell as it is forced forward over the mandrel.

The Mannessman Process is not as general an application as the Sand Core Process, as most of the alloys of copper and zinc are brittle when hot and will not stand up under the piercing operation. It is employed generally for pure copper and the eutectic alloy of copper and zinc, called Muntz Metal.

The third and last method, called the Blanking Process, is especialy applicable where a tube of large diameter or thin wall is required. In the casting operation for this method, a mould with a rectangular section is used and a flat slab is produced. These flat slabs are turned over to the rolling mill, and here are gradually rolled out between powerful rolls. The operation is a very simple one, as the bars are merely passed through various sets of rolls, each being set so as to give the bar an additional pinch. As in the drawing operation, alternate annealing and cleaning is necessary to keep the metal in workable condition.

After the sheet has been reduced to a fairly light gage it is sent to the blanking and drawing presses. Here the metal is stamped out into disks and gradually shaped and drawn from the flat disk to a seamless tube. In case a long tube is to be made, the work may be continued on a standard draw-bench, after the presses have drawn the tube to a convenient length.

In addition to seamless, as already described, there are several other kinds of tubing on the market at the present time. Some of these, as for example brazed tubing, resemble seamless closely, since the process of manufacture renders the seam practically invisible. Others are much more crude and are clearly distinguishable from seamless tubing.

The American Radio Relay League, conducting transatlantic tests in which some 15,000 to 20,000 amateur stations are participating, declares that several low-power messages sent from this country have been received in Wales. Paul Godley, representing the league abroad, sent from the Marconi plant at Carnaroon, Wales, a radio report of the success of the tests.

Airplane Controlled by Wireless.—We learn from a French report that an airplane carrying no pilot and controlled entirely from the ground by wireless, has made a successful one-hour flight. The airplane, having been started by a mechanic, ascended automatically after it had attained sufficient speed. The ascent was effected by use of a small fan the rotating speed of which, being proportional to the velocity of the plane, brought into action a mechanism for controlling the movable surfaces of the plane. For the descent, the pressure of a wireless key on the ground caused the release, underneath the airplane, of a roll of wire with a weight at the end. This weight switched off the engine and moved the rear surfaces of the plane into position for a proper landing.

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Made of extra quality cotton yarn, carefully inspected and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.
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SAMSON CORDAGE WORKS 88 Broad Street, Boston 9, Mass.

BETTER LIGHTING NEEDED IN INDUSTRIAL PLANTS.

In a paper read before the Illuminating Engineering Society, February, 1920, entitled, "A Survey of Industrial Lighting in Fifteen States," R. O. Eastman submitted some very interesting data regarding the lighting conditions in industrial institutions. The survey comprises some 446 institutions, in which lighting was considered by 55.4% as being vitally important, and by 31.6% as being moderately important, and by 13% as being of little importance. Practically 58% considered that lighting was as important as power in the operation of the plant, and a small proportion would give more attention to lighting than to anything else.

In considering the present condition of lighting as found in the various plants, only 9% ranked as excellent, about ⅓ ranked as good, 29% fair, 18.8% poor, 3.5% very poor, and 7.8% partly good and partly poor. It was found that the lighting in the offices was far superior to that in the shops; 19% being excellent, 36% good, 31% fair, and only 13% poor and none very poor.

On consulting the executives regarding what factors were most important in considering lighting, the following facts were revealed: Increase of production 79.4%, decrease of spoilage 71.1%, prevention of accidents 59.5%, improvement of good discipline 51.2%, and improvement of hygienic conditions 41.4%. Manufacturers who have good lighting appreciated its value largely from the standpoint of its stimulating effect upon output.

There is no question that any intelligent man who carefully considers the necessity for good lighting in an industrial plant, will agree that it is impossible for a person to do as good work, either in quality or quantity, in poor light as in good light, but yet the result of a careful analysis discloses the fact that only about 40% of industrial plants are furnishing good light to their workers and 60% are operating under poor lighting. It is hard to understand why such a proportion of concerns can be satisfied with a condition which is universally admitted to be a curtailer of efficiency and a prolific causer of accidents. The principal cause of this condition is that those in charge of such establishments have not given the attention to lighting that it demands. They do not know what constitutes good lighting, and in their absorbing interest of other factors of production have overlooked a vital one.

Every safety official should deeply interest himself in the lighting of his plant and insist upon good lighting as much as good goggles, good guards and other necessary accident prevention equipment. Every production manager should insist upon good lighting because the efficiency of the working force is increased by the condition of the lighting furnished. The plant physician should examine the lighting, for eye strain and eye fatigue are directly affected by poor lighting, as is the hygienic condition. Well lighted plants are invariably cleaner than poor lighted places. Plants equipped with Factrolite Glass in all windows are well lighted.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,

220 Fifth Avenue,

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Lies not alone in the quality of the work performed but also in the Service rendered.

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Lubricants which hurry equipment to the scrap pile—lubricants which require constant attention and application—lubricants whose continual dripping spells undue waste and fire risk are not efficient.

Cutting out waste and increasing output are the big problems of the present day. Proper lubrication solves both problems and

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It's saving time, labor, equipment and money in many of America's greatest industrial plants. Its density is unaffected by extremes of heat and cold. It is insoluble in water and impervious to outside chemical attacks.

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To be admitted to the Institute, the applicant must have attained the age of seventeen years and must pass examinations in Algebra, Plane and Solid Geometry, Physics, Trigonometry, English, French or German. Certificate of preparation in two units of a series of elective subjects is also required. The requirement in History may be met by the presentation of a school record of certificate grade. A division of these examinations between different examination periods is allowed. In general a faithful student who has passed creditably through a good high school, having two years' study of French and German or three years of French or German should be able to pass the Institute examinations.

Graduates of colleges, and in general all applicants presenting certificates representing work done at other colleges, are excused from the usual entrance examinations and from any subjects already satisfactorily completed. Records of the College Entrance Examination Board, which holds examinations at many points throughout the country and in Europe, are also accepted for admission to the Institute.

Instruction is given by means of lectures and recitations, in connection with appropriate work in the laboratory, drawing-room or field. To this end, extensive laboratories of Chemistry, Physics, Biology, Mining, Mechanical Engineering, Applied Mechanics, and the Mechanics Arts have been thoroughly equipped, and unusual opportunities for field-work and for the examination of existing structures and industries have been secured. The co-operative course in Electrical Engineering and that in Chemical Engineering Practice afford an unusual opportunity to combine a technical training with a direct contact with the industries.

The regular courses are of four years' duration, and lead to the degree of Bachelor of Science. In most courses the work may also be distributed over five years by students who prefer to do so. Special students are admitted to work for which they are qualified; and the degree of Master of Science, Doctor of Philosophy, and Doctor of Science are given for resident study subsequent to graduation. Opportunity for research is offered in all the departmental laboratories and in the Research Laboratories of Applied Chemistry, Electrical Engineering, Industrial Physics and Physical Chemistry.

The tuition fee, not including breakage in the laboratories, is $300 a year.

For catalogues and information, address

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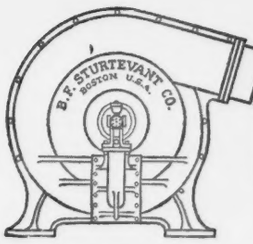

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PUTS AIR TO WORK

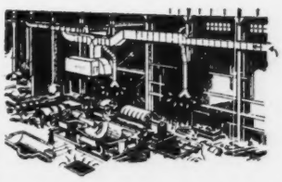
YOU frequently hear wonder expressed at the intelligence which man shows in getting natural forces to do his work.

It would be less conceited and more truthful to speak of man's extreme slowness to perceive the usefulness of these forces.

When electricity, steam, and the earth's chemical and physical forces seemed to early man but hostile devils, Nature was employing them as her trained servants. Nature used moving air as conveyor, as dryer or moistener, as purifier, as leveler, as forced draft, as heater or cooler, and as suction cleaner, when man could conceive of no implements other than his teeth and fingers.

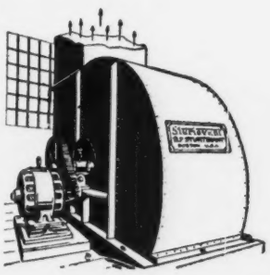
Sturtevant imitates Nature in putting air to work — and the chapter is only at its beginning.

Air brings about a large increase in production

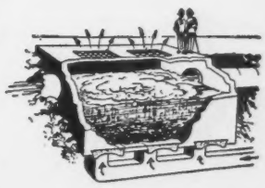


Two buildings of identical construction were devoted to the same kind of work. One building had a mechanical ventilating system. At the end of the year, production records showed that the employees in the building with the mechanical ventilating system accomplished much more work.

Supplying fresh air to your employees is a very paying investment. It increases their energy and enables them to go through the full day without a "slump." It is good business for you to furnish every employee with an abundant supply of pure air—so essential to his health and your factory's output.



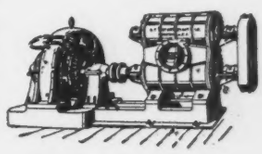
How Sturtevant Apparatus helped solve a sewage problem



An engineer of a Southern city perfected a new system of purifying sewer water.

He directed the sewage into large cement chambers at the bottom of which were gratings. Air entering these gratings was forced up through a thick layer of decaying sewage to keep the water in continual activation.

The bacteriological action of this decaying matter hastened the chemical breaking up of the incoming sewage into insoluble gases, a residue, and pure water, which flowed on to the river. The residue was valuable as a fertilizer. A Sturtevant High Pressure Blower was chosen to supply the unchanging volume and constant pressure of air so necessary to the success of this system.



Wherever there is a business there is a probable chance to use our apparatus profitably. Sixty years of experience in designing air equipment have shown us more ways to use air than most manufacturers realize; but we have only scratched the surface of the world of wonderful uses of air.

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From A Faint Blue Glow To Modern Miracles

EDISON saw it first—a mere shadow of blue light streaking across the terminals inside an imperfect electric lamp. This "leak" of electric current, an obstacle to lamp perfection, was soon banished by removing more air from the bulbs.

But the ghostly light, and its mysterious disappearance in a high vacuum remained unexplained for years.

Then J. J. Thomson established the electron theory on the transmission of electricity in a partial vacuum—and the blue light was understood. In a very high vacuum, however, the light and apparently the currents that caused it disappeared.

One day, however, a scientist in the Research Laboratories of the General Electric Company proved that a current could be made to pass through the highest possible vacuum, and could be varied according to fixed laws. But the phantom light had vanished.

Here was a new and definite phenomenon—a basis for further research.

Immediately, scientists began a series of experiments with far reaching practical results. A new type of X-ray tube, known as the Coolidge tube, soon gave a great impetus to the art of surgery. The Kenotron and Pliotron, followed in quick succession by the Dynatron and Magnetron, made possible long distance radio telephony and revolutionized radio telegraphy. And the usefulness of the "tron" family has only begun.

The troublesome little blue glow was banished nearly forty years ago. But for scientific research, it would have been forgotten. Yet there is hardly a man, woman or child in the country today whose life has not been benefited, directly or indirectly, by the results of the scientific investigations that followed.

Thus it is that persistent organized research gives man new tools, makes available forces that otherwise might remain unknown for centuries.

General Electric Company

General Office Schenectady, N. Y.

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